6.1.5 Islands

Lake Superior hosts some extensive archipelagos, notably the island chain along the Black Bay Peninsula and the Apostle Islands. There are approximately 1,763 islands in Lake Superior, most of which are in Canadian waters (Figure 6-30).

Lake Superior islands represent over 1672 km^2 and 2265 km of shoreline. They range from small barren rock outcrops to Isle Royale, which is 71 km in length (Figure 6-31). Most (71%) of islands are less than one hectare, but they represent only 0.2% of the total island area. The three largest islands, Isle Royale, St. Ignace I. and Michipicoten I. represent 62% of the total island area.

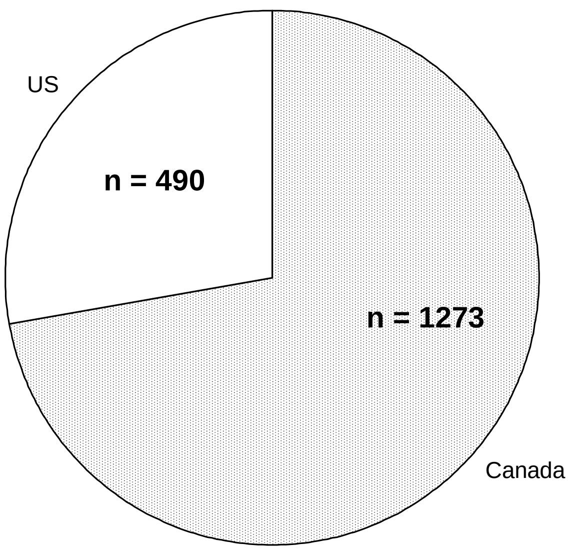


Figure 6-30. Lake Superior islands
(compiled from U.S. EPA 1994 and Environment Canada 1993)

Islands habitats contribute significantly to the biodiversity of the Lake Superior basin and provide important habitat distinct from most mainland sites. In 1995 a joint U.S.-Canada workshop to assess the State of the Great Lakes Islands, it was determined that the natural biological diversity of the islands of the Great Lakes is of global significance (Vigmostad 1998). At the 1996 State of the Lake Ecosystem Conference, islands were also specifically identified as one of seven special ecological community types recognized within the Lake Superior basin (Reid and Holland 1997).

The cold, oligotrophic nature of Lake Superior and the harsh microclimates of exposed shorelines on many islands have created conditions suitable for scattered populations of plants normally only found in arctic or alpine regions. These species were present immediately after the last Wisconsin glaciation and have been able to persist because of these climatic refugia. Many of these plants, known has "arctic-alpine disjuncts", are well-represented in Lake Superior.

Island ecosystems are greatly influenced by their isolation from mainland communities. Their isolation tends to simplify wildlife communities and provide protection from predators (Reid and Holland 1997). Islands often serve as "living laboratories" where studies of the impact of herbivores, predator-prey relationships, evolution and extinction, population dynamics, animal cycles, dispersal, and rapid population growth can be conducted.

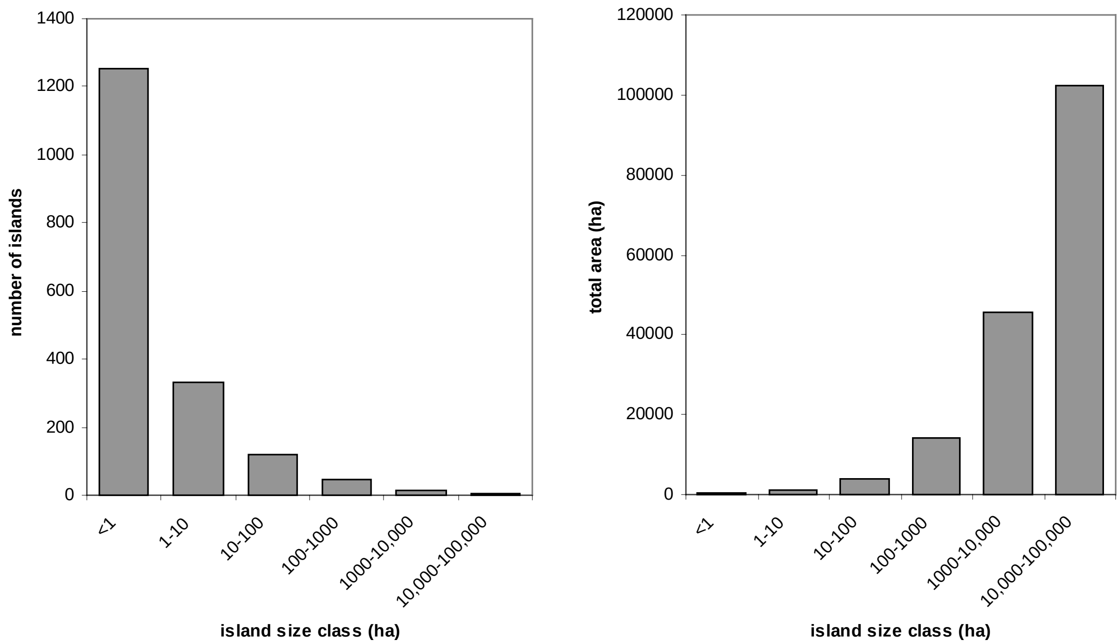


Figure 6-31. Lake Superior islands size distribution in termsof number of islands and total area (compiled from U.S. EPA 1994 and Environment Canada 1993)

Moose commonly calve on small islands and woodland caribou persist (naturally or by reintroduction) on some offshore islands as well due to the absence of wolves. Many of the Lake Superior's islands provide primary nesting sites for ring-billed and herring gulls, double-crested cormorants, and great blue herons (Blokpoel and Scarf 1991). The isolation of island habitats that affords benefits to many colonial and ground nesting birds by significantly limiting egg predation by animals such as foxes. Islands are also particularly important to migratory neotropical-nearctic species (Vigmostad 1998). Islands often provide "stop-over" refuge for birds flying over open water at night or form natural extensions to mainlands that follow critical migratory flight corridors.

Islands are extremely important to birds and other wildlife and many suggest that this use is becoming intensified as mainland habitats have become increasingly fragmented. Islands are by their nature subject to human curiosity and regularly attract human visitation to their shores.

Human intrusions can range from recreational visitation by boaters to larger scale developments that involve physical infrastructure developments.

Fortunately, many of the islands in Lake Superior enjoy protected area status. Lake Superior islands may be particularly suited to serve as biosphere reserves especially in terms of sentinels to detect the long-range transport of toxic materials (Vigmostad 1998). They are under stress, however from increased recreational use particularly sea-kayaking and boating, and changing lake levels. Due to their isolation, they are also sensitive, since if island populations are extirpated, there may be limited potential for recolonization from the mainland.

Isle Royale

Isle Royale is the largest island in Lake Superior (555 km^2) and is located approximately 22 km from the nearest mainland. Climax spruce-fir and yellow birch-sugar maples are the dominant forest cover. Isle Royale is well-known for its long-term studies of predator-prey relationships involving wolves and moose. Caribou were historically present, but white-tailed deer, black bear, raccoons and porcupines are notably absent. Isle Royale is perhaps best known of the Lake Superior Islands because of its U.S. National Park and International Biosphere Reserve designation. It is the only island based national park in the United States and is a federally designated wilderness area (Vigmostad 1996).

Apostle Islands

The 23 Apostle Islands cover over 219 km^2 and comprise approximately 291 kilometers of shoreline. A major area of Wisconsin's Lake Superior shoreline lies within the Apostle Islands National Lakeshore, which is managed by the U.S. National Park Service. The Apostle Islands include many important habitats that are protected through its status as a national park. The Apostle Islands are comprised of very old pre-Cambrian sandstone, the remnants of an old braided river channel river channel that created a unique archipelago with almost grid-like spacing. These islands are largely comprised of hemlock forests with some pine being found on sand spits. Outer Island has one of the largest remaining virgin hemlock hardwood forests in the Great Lakes region (Vigmostad 1998).

Grand Island

Grand Island lies just offshore in Grand Bay, Lake Superior, near Munising, Michigan, west of the Picture Rocks National Lakeshore. This 55 km^2 island is managed by the Hiawatha National Forest as a National Recreation Area, and features sandstone cliffs on the northwest, north and western shorelines.

Outstanding features of this island include a tombolo connecting two parts of the island and an expansive marsh on Murray Bay. The marsh includes wet meadow, shrub swamp and poor conifer swamp, features a diverse and unusual array of plants. Upland conifers dominate the northern ridges. The upland areas feature some rare plants, habitat for peregrine falcons, and a small, forested Research Natural Area. This is the only large island in Michigan's portion of Lake Superior that consists of sandstone bedrock (adjacent small islands are also sandstone), and second only to Isle Royale in size in Michigan's portion of Lake Superior. Peregrine falcons last nested on the island in 1906, but were reintroduced to the island in 1992.

Grand Island has very high biodiversity significance, primarily because of the excellent quality marsh. The Michigan Natural Areas Council has worked on developing a vegetation monitoring plan for the island in response to impact concerns that may arise from recreational uses.

Slate Islands

The Slates Islands are an archipelago of 58 islands that are approximately 13 km from the mainland shoreline near Terrace Bay on the north shore of Lake Superior. They range in size from barely exposed rocks to large islands such as Mortimer I. (8 km^2) and Patterson I. (22 km^2). The Slate Islands have exceptionally interesting and significant geology including shatter cones. They are comprised of an array of metamorphic rocks indicative of an ancient volcanic cone or perhaps thought to be the remnants of a crater from a meterorite impact (Snider 1989). However, some of the Slate Islands are relatively young having emerged approximately 3,000 years ago slowly rebounding from the weight of glaciers.

On the Canadian side, the Slate Islands provide an excellent example of how isolation from the mainland has affected wildlife communities. Many large mammals such as moose, deer or wolves have not made the crossing to the Slate Islands (in 1997 two wolves are believed to have reached the island across the ice, but have not persisted). This has enabled extremely high densities of woodland caribou to persist; they have the largest woodland caribou population (200-400 animals) in the Lake Superior basin south of their continuous distribution. The Slate Is. are also notable for populations of arctic-alpine plants and devil's club (*Oploplanux horridus*) as western disjunct also found on Porphyry Island and Isle Royale. Herring gulls nest on at least seven locations, including the Leadman Is.

The Slate Islands and surrounding waters within 400 m of shore are protected in the Slate Islands Provincial Park. There is also Canadian Coast Guard lighthouse and outbuilding on federal land on the south shore of Paterson Island.

Black Bay Peninsula Archipelago

Over 480 islands form an archipelago along the outer edge of the Black Bay Peninsula and Nipigon Bay along the north shore of Superior. They include wave-washed rocks to a number of large islands over 1000 ha each including St. Ignace Island (274 km^2), Simpson I. (73 km^2), Wilson I. (19 km^2), Edward I. (16 km^2), Fluor I. (14 km^2), Vein I. (10 km^2) and Copper I. (9 $km^{2)}$. These islands have numerous arctic-alpine communities and colonial nesting waterbirds. The archipelago has remained largely undisturbed by development and has recently been protected as a Provincial Conservation Reserve. The islands are also part of an area currently being considered for establishment of a National Marine Conservation Area.

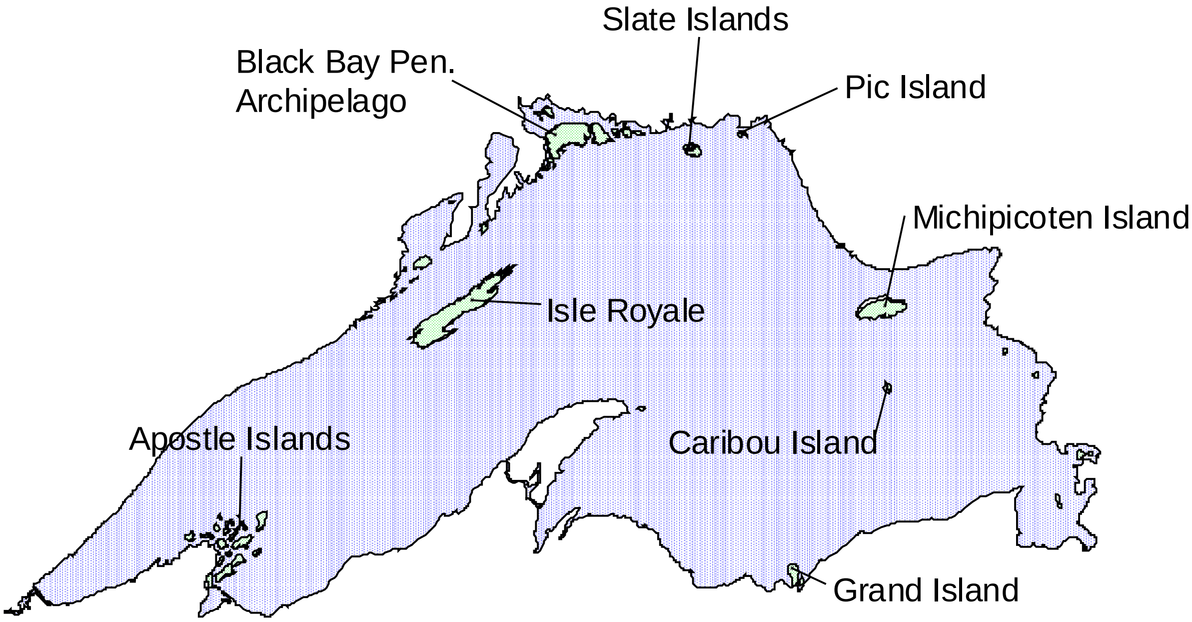


Figure 6-32. Major islands.

Michipicoten and Caribou Islands

Michipicoten is a large island (184 km^2) in eastern Lake Superior that has an introduced woodland caribou population. Caribou Island (12 km^2) is due south of Michipicoten Island, approximately 65 km from the mainland, and is notable for its isolation and as a rest stop for migrant birds. Michipicoten is a provincial park and Caribou Island is largely protected by its extreme isolation.

Pic Island

Pic Island is a small island (11 km^2) on the north shore of Superior that historically had woodland caribou and still has suitable woodland caribou habitat. Together with three adjacent islands, they have arctic-alpine plants and colonial-nesting birds. They have recently been incorporated into the adjacent Neys Provincial Park

6.1.6 Shorelines

Lake Superior's shorelines are a product of glacial activity, the influence of wave, wind, currents, and the continuous erosion and deposition of sediments. Shorelines provide a wide range of habitats depending on topography, substrate, geology, erosional processes and climate.

Shorelines offer a unique environment for plants and wildlife, substantially different from adjacent inland areas. Coastal shoreline habitats have a moderated climate and distinctive physical structures such as sand spits, bluffs and cobble beaches which address the needs of a diverse range of species.

Shoreline habitats also play a critical role for migrating wildlife, which respond to the natural barrier of water and make use of the available food sources. Open wetlands and beach areas are used by migrating shorebirds in spring and fall (Reid and Holland 1997). Many species of hawks avoid crossing the open water of Lake Superior instead making their way along shoreline bluffs on thermals and updrafts. Bird observatories at Whitefish Point Michigan, Thunder Cape Ontario and at Hawk Ridge Nature Reserve in Duluth are contributing significantly to the knowledge of shoreline migration corridors.

Human influences also tend to concentrate in or near shoreline habitats, and in some locations have had profound impacts upon the ecological integrity of these sites.

6.1.6.1 Shoreline Classification

The most comprehensive classification of Lake Superior shorelines are the Environmental Sensitivity Atlases compiled by Environment Canada (1993) and the United States National Oceanic and Atmospheric Administration (U.S. EPA 1994). Although primarily designed to assist in response to oil spills, these Canadian and U.S. atlases also provide data on Lake Superior's shoreline characteristics and features.

This classification system established a number of distinct shoreline habitat types. The U.S. approach to this shoreline classification strategy offered a slightly finer level of detail by providing a greater number of categorized shoreline types. However, both the Canadian and U.S. atlases, share a number similar physical themes, that when merged, provide a overview of shoreline habitat for the entire basin. Shoreline types are summarized in Figures 6-33 and 6-34, and Table 6-10.

Cliff

This feature includes bedrock cliffs of various heights comprised of resistant or impermeable bedrock surfaces. Many rare or unusual plant types have often been discovered in areas along these exposed, shallow soiled cliff tops where a "less competitive" growing environment offers suitable conditions for early colonization. This is the most extensive shoreline habitat type of Lake Superior, comprising 32 percent of the shore. Most cliff shores are in Canada, making up the predominant shoreline type on the outer islands and along the eastern shore (Figures 6-33 and 6-34.). In the U.S., cliffs are common in the Pictured Rocks area, Isle Royale and along the Minnesota north shore.

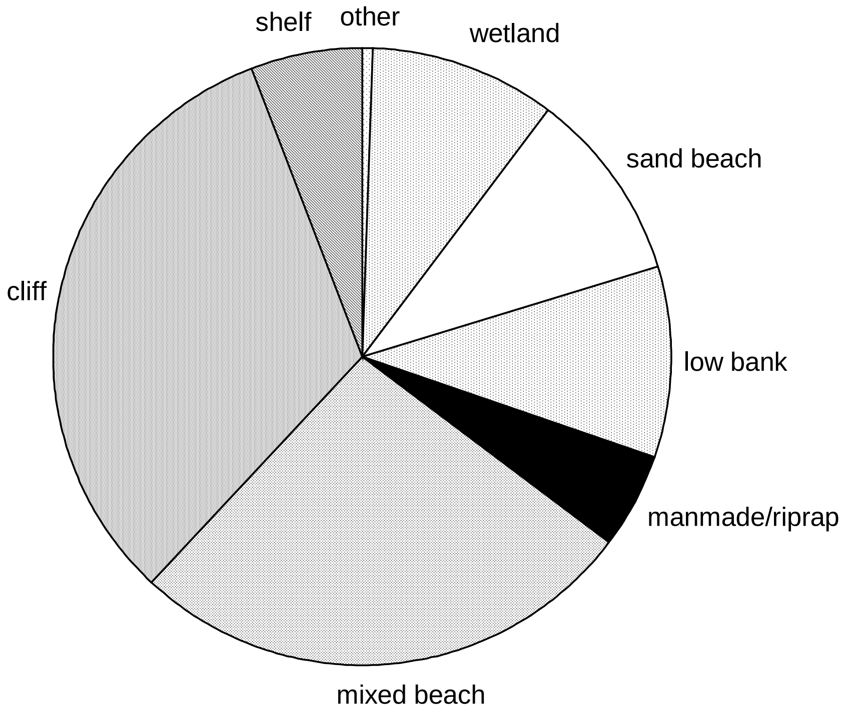


Figure 6-33. Lake Superior Shoreline

Shelf

This shoreline consists of wide flat expanses of bedrock, often also extending below normal water levels. In many cases these bedrock sites are significantly influenced by wave action. Exposure, cool temperatures and scarce soils often provide conditions very suitable for the habitation of arctic/alpine disjunct plant species. Shelving bedrock shoreline is found mainly in the U.S., particularly on Isle Royale and the Minnesota north shore.

Bluff

Bluffs, or scarps, are unconsolidated soil in an erosional state from wind, wave and surface water action. In many cases, they represent the source for sediment material and sands that are transported and deposited in locations the permit the formation of sand beaches. Bluffs are uncommon on Lake Superior, making up only 1 percent of the shoreline.

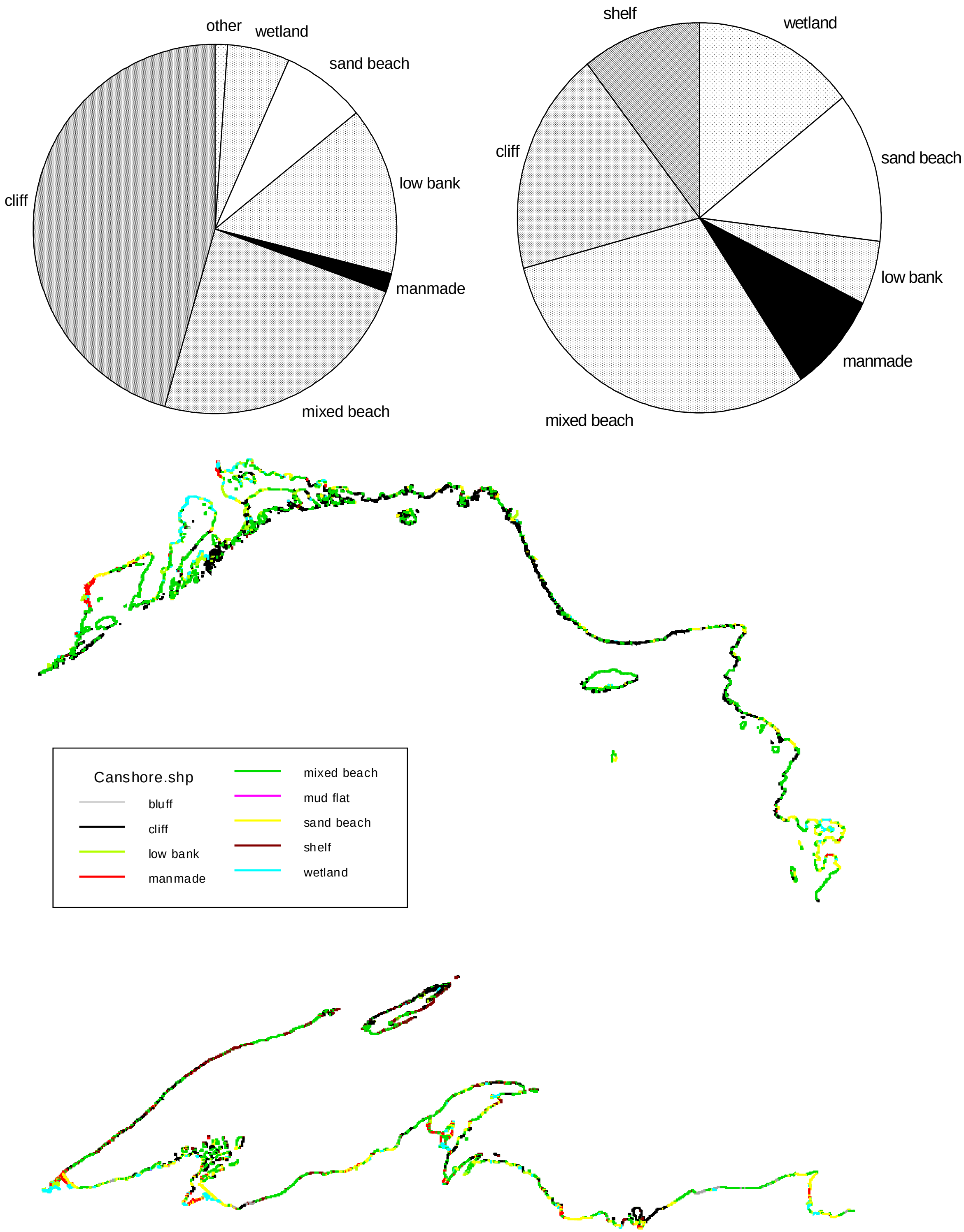


**Figure 6-34. Lake Superior shoreline types
(compiled from U.S. EPA 1994 and Environment Canada)**

Table 6-10 Physical features of Lake Superior shoreline (compiled from U.S. EPA 1994 and Environment Canada 1993)

	U.S.		Canada		Total	
	km	%	km	%	km	%
Cliff	607	18	1533	46	2140	32
Bedrock Shelf	344	10	36	1	380	6
Bluff	30	1	4	-	35	1
Sand Beach	409	12	256	8	665	10
Mixed Beach	980	30	797	24	1777	27
Low Bank	175	5	491	15	666	10
Mud Flat	2	-	1	-	3	-
Fringing Wetland	173	5	154	5	327	5
Extensive Wetland	294	9	25	1	319	5
Man-made Structure	112	3	22	1	134	2
Riprap	157	5	40	1	197	3
Total	**3283**		**3359**		**6643**	

Sand Beach

Sand beaches are formed where waves and wind and littoral drift deposit eroded particles. Artificial shoreline structures and the hardening of shorelines can have a serious impact on beaches by interrupting the process of longshore sediment transport that naturally erodes and replenishes beaches. Most sand beaches are on the eastern and southern shores of the lake, particularly in sheltered bays where wave action is less. Beaches are extremely rich areas for migrating shorebirds that feed on a variety of invertebrates. They also provide habitat for a disproportionately high number of rare species.

Mixed Beaches

Mixed beaches are a combination of sand, gravel, cobbles, and boulders, the proportions of which depend largely on the degree of exposure to wave energy. Cobble and boulder beaches are more common on wave-washed shores and sand/gravel beaches in more sheltered sites. Mixed beaches make up 27 percent of the Lake Superior shoreline. Exposed cobble beaches are largely devoid of vegetation but, in more protected areas they support mosses and lichens. Herbs, graminoids and woody plants are found farther from the limit of wave action. The spaces between cobble and other beach materials provide habitat for a variety of terrestrial and aquatic insects. Perhaps the most spectacular of this habitat type are the "raised cobble beaches" resulting from a combination of glacial rebound and receding lake levels. One of the more notable sites for "raised cobble beaches" is Cobinosh Island near Rossport, Ontario.

Low Banks

Low banks are shorelines with vegetation extending to the waterline. They make up only 10 percent of Lake Superior's shoreline. These are typically found in very well protected bays where they are sheltered from wind and wave scouring.

Mud Flats

Mud flats are typically found near the mouths of rivers where suspended sediments are deposited upon reaching the slow moving waters of Lake Superior. Less than 1 percent of Lake Superior's shoreline is mud flat.

Wetlands

Two categories of wetland shorelines are recognized. Fringing wetlands are marsh communities, characteristically found in shallow water coves protected from wind and waves. They closely border the shore to form a narrow belt of aquatic vegetation. Because urban and cottage sprawl also tend to focus lake front developments in sheltered coves, wetlands tend to be a shoreline habitat particularly susceptible to human impacts. Extensive wetlands are larger (up to 1 to 2 km long) and occupy shallow coves with stream outlets. On Lake Superior marsh communities are the most common type of broad wetland. These two wetland shoreline types make up 5 percent of the Lake Superior shoreline, with most of the extensive wetlands in the U.S.

Manmade Structures

This category includes retaining walls, harbour structures, sheet piling, breakwaters, and riprap. This type of shore is usually found in close proximity to urban/industrial areas. Riprap is comprised of rock material placed to protect shoreline property. Solid straight-line man-made structures, provide little habitat for terrestrial or aquatic life. In some instances, riprap can enhance fish habitat by providing a suitable spawning substrate, but habitat for plants and animals dependant of soft substrates is lost. Gulls frequently use breakwaters for resting, feeding and nesting. Collectively, manmade shorelines make up 5 percent of the Lake Superior shore, mainly in the U.S.

6.1.7 Wetlands

Wetlands often form the link between the terrestrial environment and Lake Superior. They provide habitat for fish and wildlife, protect shoreline areas from erosion, buffer runoff following storm peaks and contribute to the diversity of habitat types in the basin.

Wetlands can be classified in different ways. One of the most widely accepted classifications recognizes five major categories of wetlands. **Bogs** are peatlands (ie. wetlands with more than 40 cm of organic soil) where the surface is isolated from contact with mineral rich ground water. They are acidic and nutrient-poor. **Fens** are peatlands that are nourished by groundwater flow and are therefore richer than bogs. **Swamps** are dominated by trees or tall shrubs and have standing or gently moving waters. They have organic or mineral soil. **Marshes** are flooded by standing or slowly moving water for all or part of the year and are usually associated with lakes or streams. **Shallow open water wetlands** are like marshes, but are dominated by submergent and floating-leaved plants (NWWG 1988).

Wetlands can also be classified by and aquatic system (lacustrine, riverine, estuarine, palustrine) and site type (e.g. open embayment, barrier beach lagoon, dune and swale complex, etc.) (Chow-Fraser and Albert 1998).

Total wetland coverage (excluding marshes and shallow water) is estimated at 15 percent of the U.S. basin (Table 6-11). Estimates range from 781 km^2 (10 percent of the basin) in Wisconsin to 3379 km^2 (21 percent of the basin) in Minnesota. A different estimate of Minnesota's wetland area using National Wetland Inventory (NWI) data puts the total for the basin at 31 percent of the land base (MPCA 1997). Differences in estimates of total wetland area are due to different techniques and definitions of wetlands. Digital NWI data is unavailable for Wisconsin and Michigan.

Table 6-11 Wetland area for the U.S. Lake Superior basin (exclusive of open water and deep marsh wetlands) (data from Lake Superior Decision Support Systems)

Wetland Class	Total Area (km^2)	% of Basin
Michigan		
Forested	1935	10
Non-Forested	366	2
Subtotal	2301	11
Minnesota		
Forested	3067	19
Non-Forested	312	2
Subtotal	3379	21
Wisconsin		
Forested	699	9
Non-Forested	82	1
Subtotal	781	10
Total U.S.	**6461**	**15**

Minnesota's wetlands are mostly bog, fen and swamp, typically in palustrine environments. Marshes and shallow open water are mostly found on inland lakes and streams (Wright and others1988, MPCA 1997) (Figure 6-35).

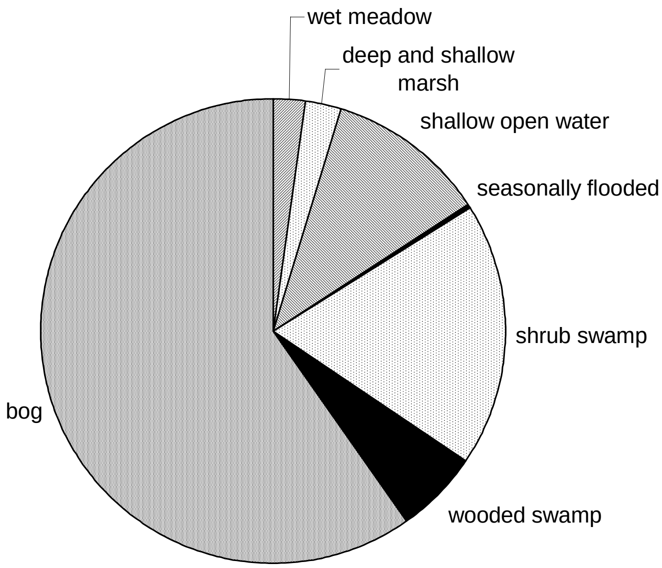


Figure 6-35. Proportions of wetland types for the Minnesota Lake Superior basin - "bog" includes bog and fen (MPCA 1997)

The most heavily concentrated areas of wetland in the U.S. basin are in western Minnesota and eastern Michigan (Figure 6-36). The St. Louis River watershed is 41 percent wetland, with extensive peatlands in the central watershed (MPCA 1997). Large peatlands in Luce and Chippewa counties in Michigan are also noteworthy (Crum 1988).

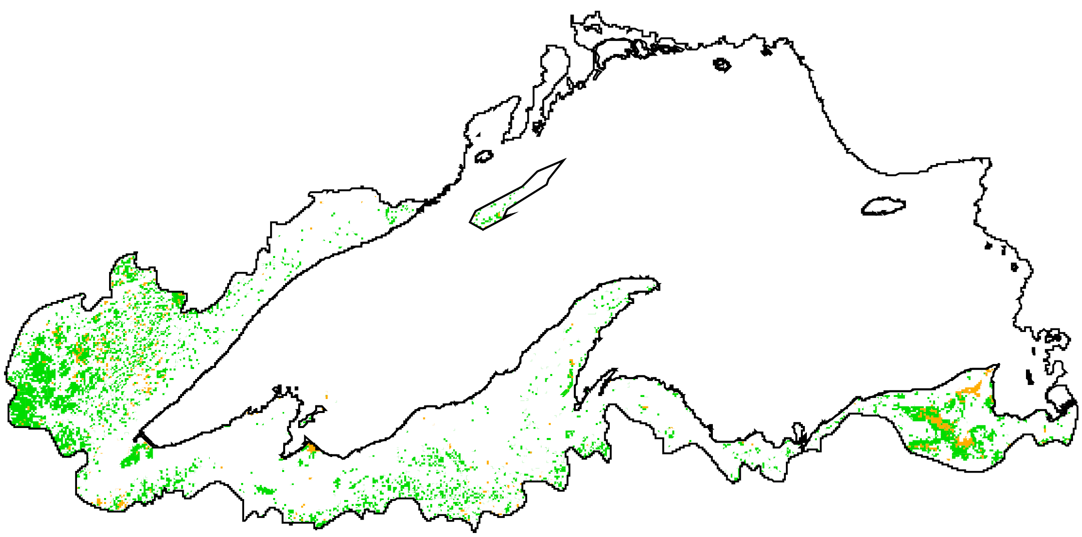


Figure 6-36. Forested (green) and non-forested (orange) wetlands in the U.S. Lake Superior basin (Lake Superior Decision Support Systems data)

Detailed data are unavailable for Ontario, but the area surrounding the basin is estimated at 6 to 25 percent wetland cover by area (Figure 6-37) (NWWG 1988). Wetlands in Ontario are concentrated in the eastern and western ends of the basin. The Ontario basin is within the “Low Boreal” and “Humid Mid-Boreal” wetland regions, where the most common wetland types are bogs, fens and coniferous swamps.

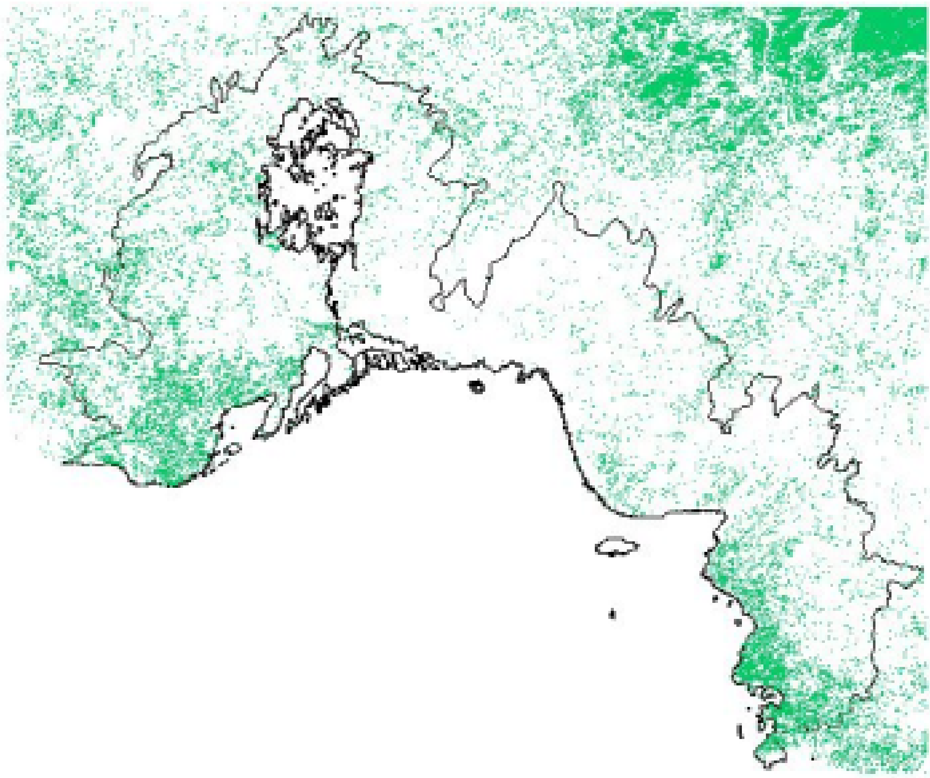


Figure 6-37. Wetlands in the Ontario Lake Superior basin (OMNR data)

6.1.7.1 Coastal Wetlands

Coastal wetlands make up 10 percent of the Lake Superior shore (Table 6-11, Figure 6-38) mostly associated with protected bays, estuaries and barrier beach lagoons (Chow-Fraser and Albert 1998). Lake Superior coastal wetlands consist of small lacustrine marshes dominated by spikerush (*Eleocharis smallii)* and hardstem bulrush (*Scirpus acutus)* with richer submergent communities in more sheltered estuaries. Narrow bands of wet meadow with bluejoint grass (*Calamagrostis canadensis*) and sedges (*Carex* spp) and thicket swamp with willows (*Salix* spp.) and alder (*Alnus incana*) occupy the seasonally-flooded zone. Fens are found above the level of contact with lake water, where organic soil accumulates. Sphagnum moss and ericaceous shrubs are the dominant plants.

In Ontario, coastal wetland development is restricted by high wave energy. Extensive coastal wetlands are confined to Thunder Bay, Black Bay and Nipigon Bay (Figure 6-38). Fringing wetlands are associated with Black Bay Peninsula and Nipigon Bay. There is very little coastal wetland on the eastern half of the Ontario shore. Ontario's coastal have a total area of approximately 4400 ha (Wilcox and Maynard 1996). Because of their scarcity, Ontario's coastal wetlands are very important to fish and wildlife (Maynard and Wilcox 1997). Only about 10 coastal wetlands have been evaluated on Lake Superior, mostly near Thunder Bay (Maynard and Wilcox 1997). At least 3,500 ha of coastal wetland remains to be evaluated (Wilcox and Maynard 1996).

The U.S. side of the lake has approximately 17,400 ha of coastal wetland (Wilcox and Maynard 1996). Coastal wetland is rare on the Minnesota northshore due to the smooth steep shoreline. The stretch of shoreline from Duluth to Marble Point, Wisconsin has perhaps the most abundant and richest coastal wetlands on Lake Superior. Most are associated with the Lake Superior Clay Plain where estuaries and barrier beaches offer shelter from waves and wind (Epstein and others 1997). Wisconsin's coastal wetlands have been thoroughly inventoried and described (Epstein and others 1997).

Michigan's coastal wetlands are scattered at stream mouths from the Keweenaw Peninsula to Sault Ste. Marie. Extensive dune and swale and barrier beach wetlands are along the sandy shore between Whitefish Bay and Sault Ste. Marie (Chow-Fraser and Albert 1998).

6.1.7.2 Threats

The greatest threats to Lake Superior's wetlands are water level regulation and site-specific stresses such as shoreline development (Chow-Fraser and Albert 1998). Other threats include invasive species and diminished water quality (Epstein and others 1997).

Loss of wetland habitat has been small in Cook (0 percent loss) and Lake (2 percent loss) counties, Minnesota (MPCA 1997), but most of the St. Louis River estuary wetlands at Duluth / Superior have been lost since the early 1900's (Epstein and others 1997). The wetlands of the Apostle Islands, Bad River and Kakagon Slough are largely intact (Chow-Fraser and Albert 1998).

Wetland loss in Ontario has not been quantified, but is probably low (0 – 25 percent) for most of the basin, given the low intensity of land use (Detenbeck and others 1999). In local areas, however, wetland losses are substantial. Wetland area around the city of Thunder Bay was has declined by over 30 percent since European settlement (NWWG 1988). Lake Superior shoreline wetlands are a particular concern in Ontario, given their scarcity and proximity to developed areas. Continued cottage development at Cloud Bay, Sturgeon Bay and Pine Bay threatens wetlands (Maynard and Wilcox 1997).

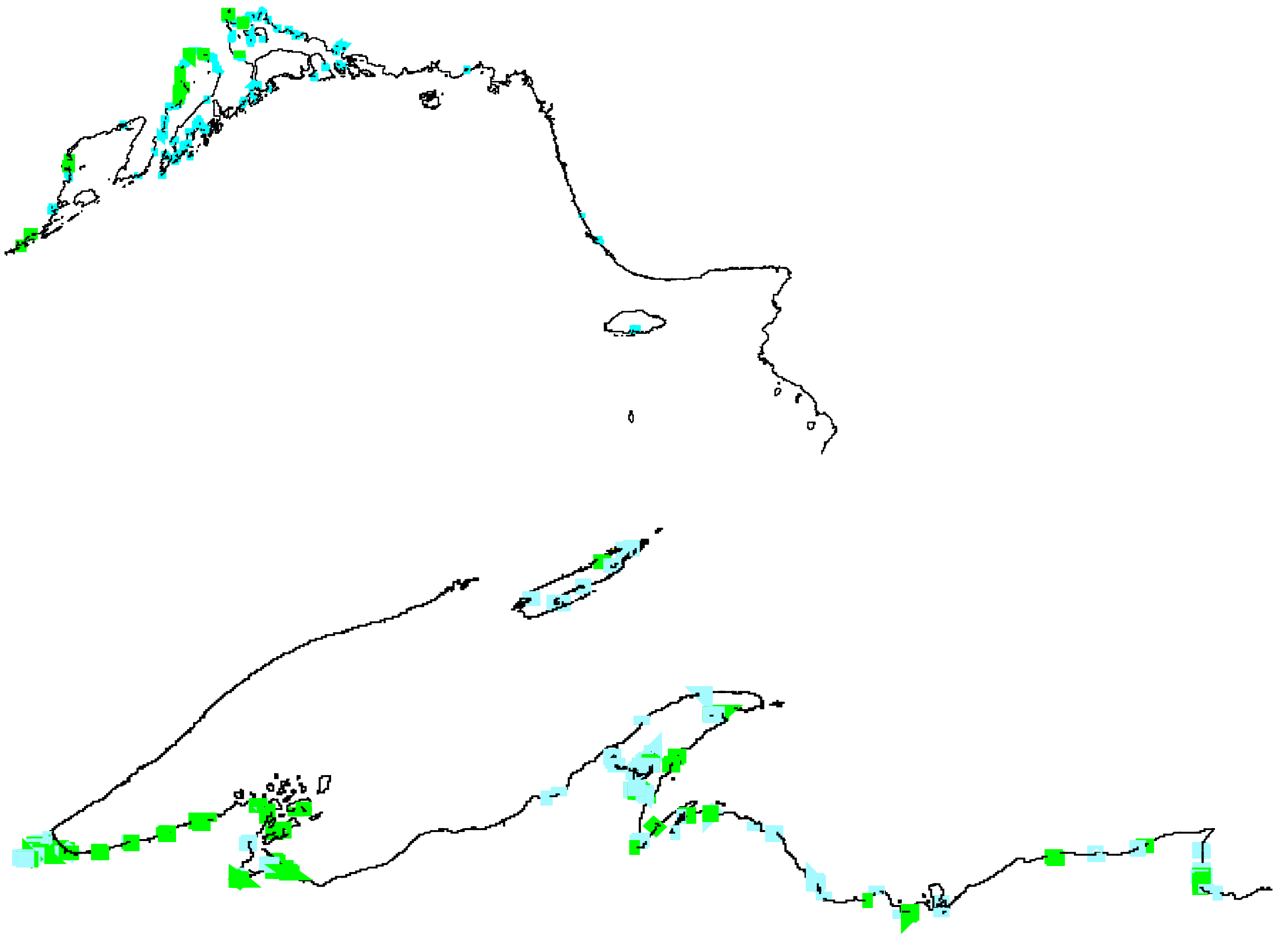


Figure 6-38. Lake Superior shoreline wetlands: extensive (green) and fringing (blue) (compiled from U.S. EPA 1994 and Environmental Canada 1993)

No estimate is available for the amount of coastal wetlands lost on Lake Superior. No large-scale losses have occurred along the north shore because the shoreline is remote and sparsely populated. However, considerable wetland area has been lost within the Areas of Concern at Thunder Bay, Nipigon Bay, Jackfish Bay, and Peninsula Harbour due to shoreline modification and urban encroachment (Wilcox and Maynard 1996). On the other Great Lakes, 11 – 100 percent of historical wetland area has been lost (LSBP 1995a). Nutrient enrichment and toxic contamination of waters and sediments and modified water level fluctuations are other potential threats to Lake Superior wetlands (Wilcox and Maynard 1996).

Water level regulation on Lake Superior has affected all coastal wetlands by restricting the natural flooding and drawdown cycle. In an unregulated wetland, periodic flooding kills back woody species along the fringe, allowing less competitive wetland plants to occupy the zone. Drawdown below the average water level allows the seed bank to germinate and promotes oxidation of substrates. Maintaining relatively constant water levels result in a smaller and less diverse wetland zone. On Lake Superior, although the flooding – drawdown cycle hasn't been altered substantially, the extreme low water levels are probably not frequent enough to maintain natural wetland conditions (Maynard and Wilcox 1997). No data on changes in wetland vegetation due to water level regulation are available. Similar effects occur on wetland on inland lakes and streams with altered water level regulation (Wilcox and Whillans 1999).

Shoreline alteration influences wetlands, both through direct loss of wetland area and disruption of hydrological and sedimentation processes. Wetlands enclosed by groins, dykes and breakwalls have reduced supplies of sediments that naturally nourish the shoreline and replace eroded sediments (Maynard and Wilcox 1997). By obstructing natural disturbances, such as storms and ice-scour, man-made structures cause shifts in plant species composition of enclosed wetlands.

6.1.8 Tributary Streams

Lake Superior has an estimated 1,525 tributaries (840 in the U.S. and 685 in Canada) (Lawrie and Rahrer 1973). These include permanent as well as intermittent streams. In addition, there are thousands of tributaries that flow into inland lakes or other streams rather than directly into Lake Superior) (Figure 6-39). Collectively, these streams add up to over 30,000 km of habitat (Figure 6-40).

Many of the tributaries are short, due to the relatively small, steep watershed. Some of the largest tributaries are the Nipigon, St. Louis, Kaministiquia, and Pic rivers (Figure 6-41, Table 6-12).

The wide diversity of geology and soils around the basin contribute to a diversity of different stream habitats. However, streams have not been thoroughly inventoried or classified and the various jurisdictions around the basin differ in the amount and kinds of information available. The Nature Conservancy has started an initiative to classify all streams in the basin using geographical information system data (Jonathan Higgins, Michele DePhilip personal communication), but results are not available yet.

In general terms, many streams are high gradient, cold water environments supporting brook trout, sculpins, dace and introduced salmonids. Slower moving low gradient streams support cool and warmwater fish communities. Wisconsin has the most exhaustive stream inventory (Turville-Heitz 1999). Most Wisconsin streams that have been classified are coldwater trout streams (Figure 6-42). Minnesota north shore streams are numerous and short with steep gradients. They are "…deeply entrenched and characterized by swift flows, many rapids and waterfalls, and especially steep gradients in the lower 3 to 5 miles before entering Lake Superior…" (MPCA 1997). Streams in the St Louis River watershed have smaller gradients.

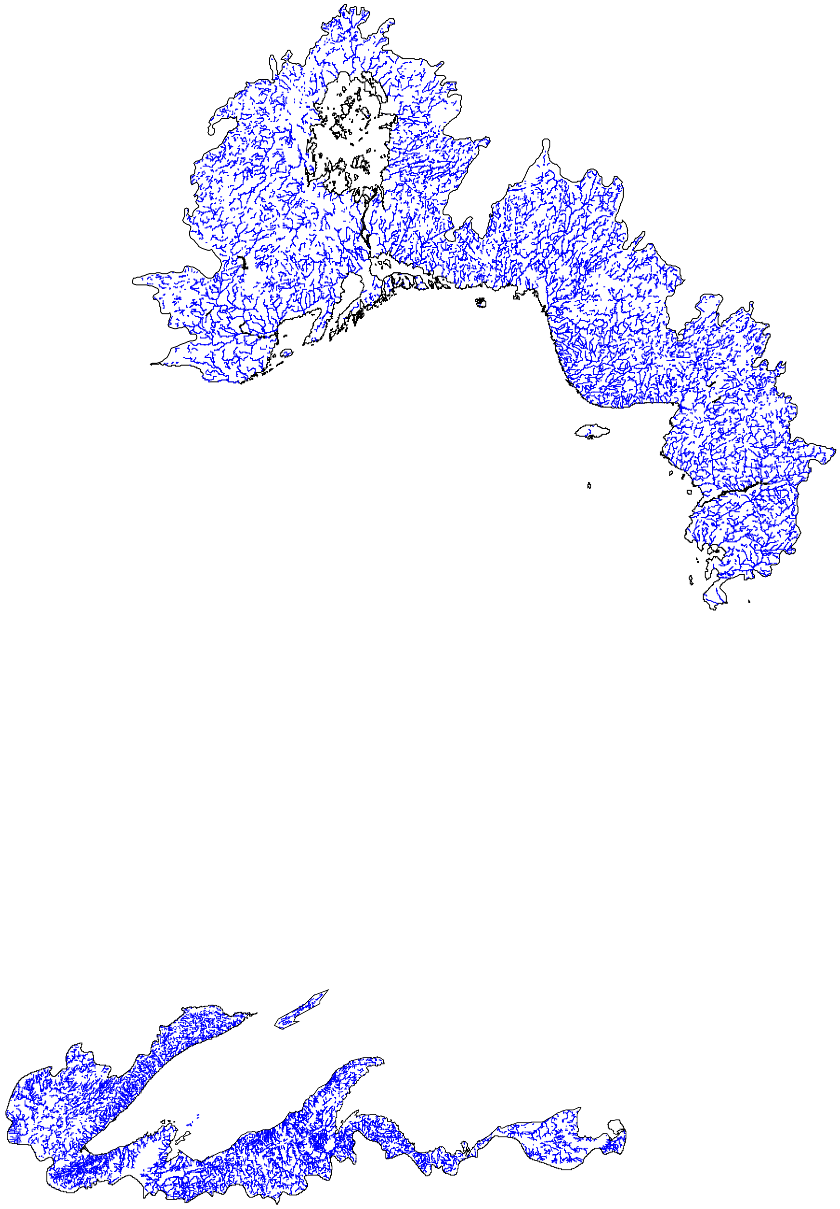


Figure 6-39. Perennial streams in the Lake Superior basin (Lake Superior Decision Support Systems and OMNR data) - Note stream mapping standards differ between jurisdictions

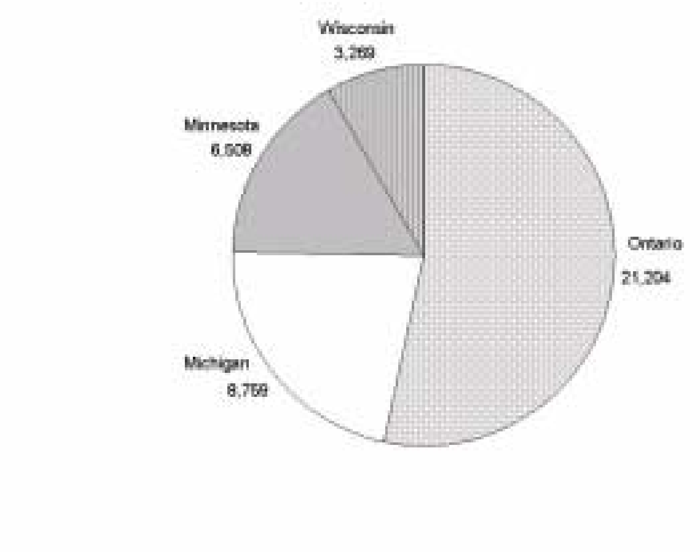


Figure 6-40. Perennial stream lengths (km) in the Lake Superior basin (derived from OMNR and Lake Superior Decision Support Systems NRRI data) Note stream mapping standards differ between jurisdictions

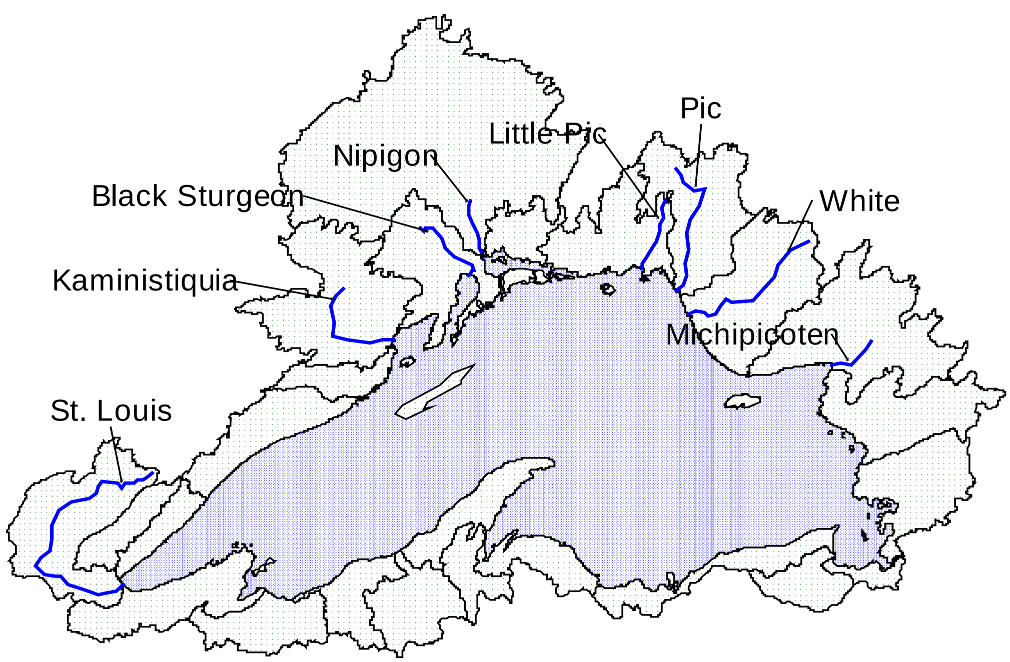


Figure 6-41. Major watersheds and rivers (Lake Superior Decision Support Systems data)

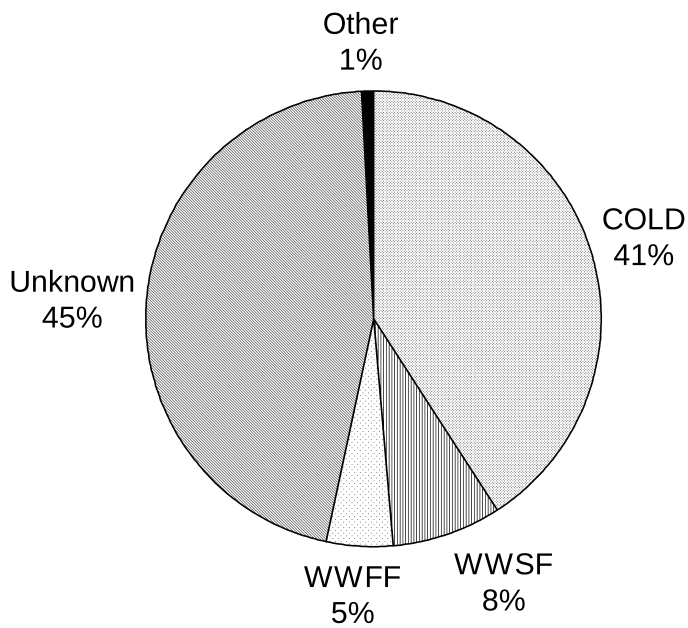


Figure 6-42. Classification of Wisconsin streams in the Lake Superior basin COLD is cold water fishery including trout stream; WWSF is warm water sport fishery; WWFF is warm water forage fishery; "Other" includes limited forage fishery and limited aquatic life (from Turville-Heitz 1999).

Table 6-12 Some major Lake Superior tributaries (OME 1992, MPCA 1997)

River	Flow (m^3/s)	Length (km)
Nipigon	331	50
St. Louis	258*	288
Pic	65	-
Kaministiquia	61	-
Michipicoten	36	128
Little Pic	19	158
Black Sturgeon	19	90

* approximate value determined downstream from confluence of Cloquet River

Sedimentation, changes in runoff on the landscape level related to clearcutting, agriculture and urbanization have greatly changed habitats on the lower Great Lakes. Impacts on Lake Superior are smaller due to the lower human population, but local problems do occur and the cumulative effects of many small changes are unknown.

6.1.8.1 Accessible Stream Length

The length of accessible tributary stream habitat is a potential limiting factor for Lake Superior's migratory fish populations. Accessible stream length can be limited by natural (e.g. falls) or man-made (e.g. dams) barriers.

On the Canadian side, there is an estimated 1091 km of stream available to anadromous fishes (Steedman 1992). The U.S. side has an estimated 3171 km of accessible stream (Table 6-13). The method of determining the length probably differs between jurisdictions. Data for individual streams is in presented in Addendum E.

Accessible stream length has decreased due to construction of dams, lamprey barriers, and other man-made structures. Estimates of the decrease in available habitat are not available. Power dams are the lowest barrier on some significant tributaries, including the Black, Michipicoten and Montreal rivers, but the decrease in accessible stream is not easily determined because dams sometimes are constructed at natural barriers (falls or rapids).

Removal of man-made barriers and construction of fish passage devices, such as fish ladders can increase the amount of available stream habitat.

Table 6-13 Summary of Lake Superior tributaries known to contain anadromous fishes (compiled by Mark P. Ebener; Ontario total from Steedman 1992)

Management Unit	Available habitat (km)	Number of tributaries										
		Chinook salmon	Coho salmon	Atlantic salmon	Pink salmon	Rainbow trout	Brown trout	Brook trout	Lake trout	Lake white fish	Walleye	Lake sturgeon
MN-1	218	4	1			21	1	10			1	1
MN-2	12	1	1			24	1	22				
MN-3	35	1				20		20			1	1
WI-1	250	4	3			6	6	1			5	
WI-2	273	6	10			10	8	3			3	1
MI-1	77		1			7		11				
MI-2	900	4	6	2		18	7	9			4	
MI-3	200	1	8			19	5	11			1	

Table 6-13 Summary of Lake Superior tributaries known to contain anadromous fishes (compiled by Mark P. Ebener; Ontario total from Steedman 1992)

Management Unit	Available habitat (km)	Number of tributaries										
MI-4	457	1	12		4	24	5	14			9	1
MI-5	217	8	8		7	13	5	12			7	
MI-6	142	4	7		5	13	4	7		1	3	
MI-7	94	3	5		6	6	1	5			2	
MI-8	296	6	9		5	12	2	8			3	1
ON-1	6				1	3		3			2	
ON-2	?										3	
ON-4	?	1									5	
ON-5	?	1									5	
ON-6	22	1	1		1	2		1			1	
ON-7	17	2	2		2	2		2			2	1
ON-10	?	1						2				1
ON-11	?							2			2	1
ON-12	?										2	
ON-18	6	1	1	1	1	2		1			1	
ON-19	?										1	
ON-23	2	4	1			3		2			4	1
ON-24	?					1		1				
ON-28	?	1				1			1		2	1
ON-31	?							2			1	
ON-33	18	1	2		1	4		3	1		6	
ON-34	37	1	1		1	1					3	1
U.S. Total	**3171**	**43**	**71**	**2**	**27**	**193**	**45**	**133**	**-**	**1**	**39**	**5**
ON Total	**~1091**	**14**	**8**	**1**	**7**	**19**	**0**	**19**	**2**	**-**	**40**	**6**

6.1.8.2 Stream Water Quality

Ontario

The Ontario Ministry of the Environment (OME) monitors 37 streams background levels and to assess impacts of point source pollution. These sites include the mouths of some major tributaries. A summary of selected stream parameters is presented in Addendum D. OMNR has conducted surveys on 65 tributary streams (Addendum C).

Seventeen Ontario streams have habitat impairments due to point source pollution, siltation, urban runoff and other causes (Table 6-14). Five of these streams (McVicar Creek, McIntyre River, Neebing River, and Kaministiquia River) run through the City of Thunder Bay and receive urban runoff as well as industrial effluent. Four streams near the Hemlo gold fields are contaminated by mine waste (Cedar Creek, Fox Creek, Hayward Creek, Upper Black River). A

1992 report (OME 1992) noted some improvements in pulp mill effluent and urban sources, but there are continued problems, especially during low water levels. No current (post 1992) summary is available.

Fish habitat has also been degraded by historical logging practices, such as log drives, logging of banks and erosion from road crossings (Lawrie and Rahrer 1973). Logging, and associated road crossings, has taken place in all the major watersheds. In Ontario, application of habitat guidelines (OMNR 1988a, 1988b) have improved stream side logging practices, but landscape-level impacts of logging impacts across the watershed are unknown. Ontario streams have a wide range of natural turbidity levels due to differences in soil types. This makes it difficult to distinguish the influence of natural erosion processes and man-made causes.

Table 6-14. Ontario streams with habitat impairments (OME 1992, OMNR unpublished data)

Stream	Impairment	Source of Impairment	Receiving water
Agawa River	Channelization		Lake Superior
Blackbird Creek	BOD, pH, coliform bacteria	Pulp and paper mill effluent	Lake Superior
Cedar Creek	Phosphorus, nitrogen, fecal coliform bacteria	Diffuse source – extractive industrial land	Black River, Pic River
Current River	Fecal coliform bacteria	Rural and urban runoff	Lake Superior
Deadhorse Creek	Siltation		Lake Superior
East Davignon Creek	Siltation, pollution, low summer flow, BOD, high temperatures,	Urban runoff, industrial effluent	Lake Superior
Fox Creek	Sulphates, metals, pH	Diffuse source – extractive industrial land downstream from mine seepage	Black River, Pic River
Hayward Creek	Conductivity, chlorides, sulphates, metals, phosphorus, pH	Mine effluent	White River
Little Cypress R.	Erosion, low summer flows, High temps, barrier	Highway washout	Lake Superior
Little Pic River	Siltation		Lake Superior
Lower Kaministiquia River	BOD, suspended solids, phosphorus, nitrogen, metals, fecal coliform bacteria	Industrial point sources, pulp and paper mill effluent, sewage treatment plant	Lake Superior
McIntyre River	Chlorides, conductivity, metals	Rural and urban runoff	Lake Superior
McVicar Creek	Alkalinity, chlorides, conductivity	Urban runoff	Lake Superior
Michipicoten	Water fluctuations	Power dam	Lake Superior

Table 6-14. Ontario streams with habitat impairments (OME 1992, OMNR unpublished data)

River			
Neebing River	Alkalinity, phosphorus, organic nitrogen, fecal coliform bacteria	Rural and urban runoff	Lake Superior
Rudder Creek	Alkalinity, BOD, chlorides, conductivity, nutrients, suspended solids, sulphates, fecal coliform bacteria	Municipal sewage	Pic River
Upper Black River	Sulphates, conductivity, ammonia	Diffuse source – extractive industrial land and point source, mining	Pic River

Minnesota

The Minnesota Pollution Control Agency (MPCA) assesses selected streams for Aquatic Life Use Support, "to determine if waters are of a quality to support the aquatic life that would be found in the stream under the most natural conditions" (MPCA 1997). The assessment is based on water chemistry data, biological and habitat information and a survey of local resource managers. Note that the data presented in and is based on a subset of the streams.

Water quality in north shore streams is typically quite good (Table 6-15) (MPCA 1997). "Threatened" streams do not show signs of degradation, but are likely to show signs of degradation due to future changes in the watershed. Turbidity, metals, and habitat alteration are the most common indicators of impairment with silviculture, construction and land disposal as the suspected pollution sources (Figure 6-43).

The 39 km of the Nemadji River that has been assessed is "not supporting" due to turbidity and habitat alteration from a hydroelectric dam. The 12 km of the Cloquet River that has been assessed is not supporting due to metals from non-point sources.

The lower St Louis River is polluted from industrial effluent, stormwater runoff, and other sources. This area is covered by a Remedial Action Plan has shown improvements in water quality. Contaminated sediments, stormwater runoff and leaky landfills continue to pollute the river. In addition to water quality impairments, human activity has altered habitat in more than 58 percent of the St. Louis River Estuary through dredging, shoreline modification and filling of wetlands.

Table 6-15 Minnesota stream assessments for aquatic life (MPCA 1996)

Watershed	Length Assessed (km)	Fully Supporting	Threatened	Partially Supporting	Not Supporting	Not Attainable
Lake Superior – North	251	23%	77%	-	-	-
Lake Superior – South	182	3%	41%	23%	34%	-
St. Louis River	432	-	23%	3%	72%	3%
Cloquet River	12	-	-	-	100%	-
Nemadji River	39	-	-	-	100%	-

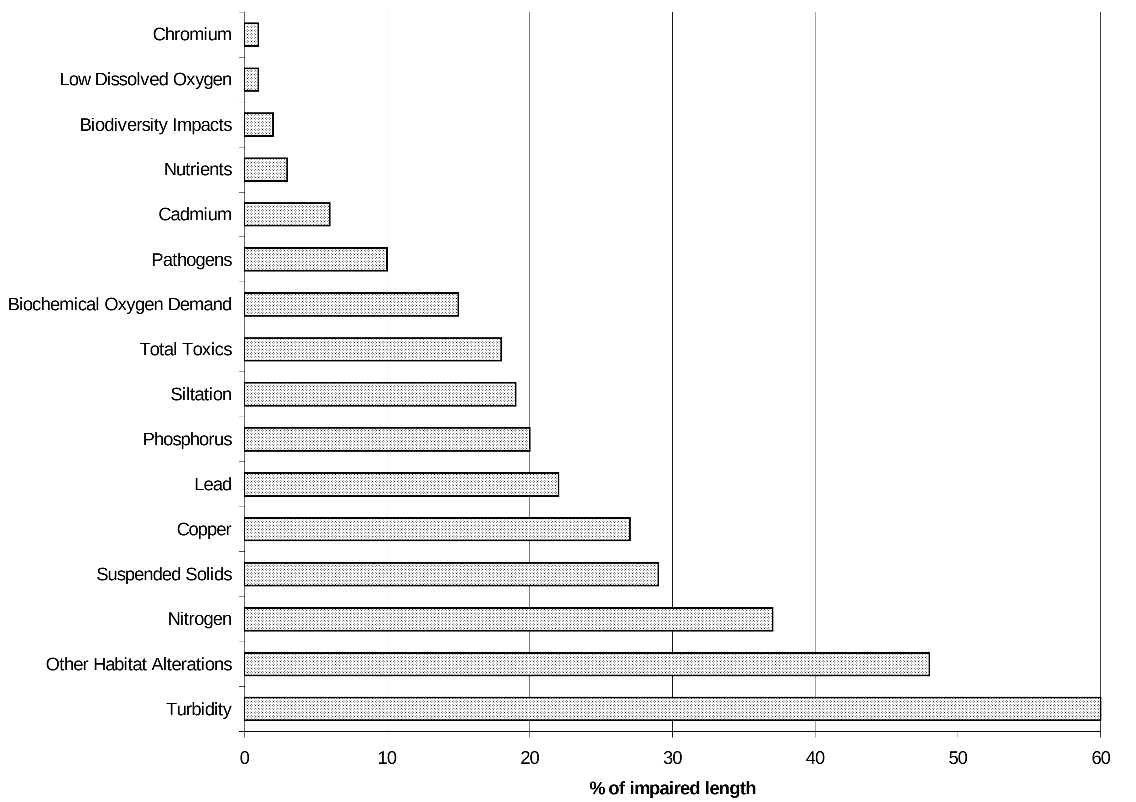


Figure 6-43. Causes of Habitat Impair

Wisconsin

Wisconsin has a detailed inventory and discussion of habitat conditions of streams in the Lake Superior Watershed (Turville-Heitz 1999). Table 6-16 summarizes the habitat conditions of all Wisconsin Lake Superior tributaries. The relatively large amount of Threatened habitat is mostly due to potential impacts of exotic species or land use activities within the watershed, even where there are no observed effects.

One of the major sources of turbidity and sedimentation in Wisconsin tributaries is related to the unstable red clays soils of the Lake Superior Clay Plain (see the following text box).

Table 6-16 Wisconsin Lake Superior tributaries (from Turville-Heitz 1999)

	Watershed	**No. Streams**	**Total Stream Length (mi)**	**Watershed Area (mi^2)**	**Supporting Potential Use (%)**				
					Full	**Part**	**Not**	**Thr**	**Unk ***
LS01	St. Louis and Nemadji rivers	78	284	159	7	12	3	22	78
LS02	Black and Upper Nemadji rivers	52	180	126	12	-	-	45	88
LS03	Amnicon and Middle rivers	107	384	289	23	-	-	-	77
LS04	Bois Brule	72	165	195	27	2	-	49	71
LS05	Iron River	36	147	218	9	-	-	79	91
LS06	Bayfield Peninsula Northwest	56	172	236	1	-	-	52	99
LS07	Bayfield Peninsula Southeast	56	142	302	3	2	4	56	91
LS08	Fish Creek	35	115	157	9	23	3	36	66
LS09	Lower Bad River	18	129	124	-	-	-	95	100
LS10	White River	67	271	360	tr	tr	-	75	99
LS11	Potato River	46	160	140	2	-	-	47	98
LS12	Marengo River	85	261	218	-	-	-	47	100
LS13	Tyler Forks	46	124	79	-	-	-	35	100
LS14	Upper Bad River	62	194	135	-	-	-	28	100
LS15	Montreal River	80	264	226	19	-	-	62	81
LS16	Presque Isle River	53	91	108					
	Total	**949**	**3083**	**3072**					

* stream can be both “Threatened” and “Unknown” if potential impacts have been identified

The St. Louis and Nemadji watershed has been discussed in the Minnesota section. Tributaries within the Wisconsin part of the watershed with impaired water quality include Crawford Creek, an unnamed Drainage to Crawford Creek, and Newton Creek. Impairments are due to sediment contamination, point sources of pollution, aquatic toxicity and other contaminants.

Habitat in the Fish Creek Watershed has been impacted by pathogens from sewage treatment plant and stormwater runoff from the City of Ashland. Other concerns are habitat loss, sedimentation and turbidity from unfenced pastureland, barnyard runoff, and logging (Turville-Heitz 1999).

Stream habitat in the Montreal River watershed has been altered by hydrological modification. There are only six hydroelectric dams in the Wisconsin basin, three of which are in the Montreal River watershed (the others are in the White, Iron, and St. Louis watersheds). Wisconsin's watersheds are small and provide inconsistent flows. Another 5 or so former dams have been removed (Turville-Heitz 1999).

Changes in Pre-European Forest Covertype on the Red Clay Plain and Stream Erosion (J. Gallagher)

Between the late 1800s and early 1900s, the Lake Superior Clay Plain underwent substantial disturbance in association with European settlement. Effects of this disturbance still impact hydrologic processes in the clay plain today. Analyzing what disturbance forces took place, how they changed the forest landscape, and the impacts these had on forest hydrology can be helpful to planners who are applying management practices to improve stream habitat.

Although the disturbance period was initiated by timber harvest, primarily of white pine, fire and artificial drainage of upland surface water associated with agriculture and road development produced some of the greatest changes to the landscape.

Geologically speaking this landscape is relatively young. The last glacial deposit occurred between 9500-11,000 years BP, when receding glacial ice retreated into the Superior basin and than later advanced, depositing a thin layer of clay till, Miller Creek Formation, over a deeper previously deposited coarser textured till, Copper Falls Formation (Clayton, 1984).

Young glacial landscapes generally have rapid erosion rates with geologic aging. Compounding this fact is the manner that the deposits occur. The clay till has fine clay texture and is strongly bonded. Beneath the clay lies coarse textured till, loosely bonded, and unconsolidated. Major streams have long ago cut through the clay till into the unconsolidated till. Water flowing in these streams, particularly during flooding, has been cutting away the loosely bonded till well before pre-European settlement. Streams eroding loosely aggregated channel sides are not uncommon, however the existence of the surface red clay cap has a two-punch effect in producing high erosion rates along these clay plain streams.

- Strongly bonded clay caps above a bend in a stream channel, where the loose material is being eroded, slows the stabilization process of the slope above the channel. This results in long steep mass wasting slopes immediate to the stream channel.
- Water infiltration rates in uplands covered by red clay till are very slow. Runoff is very rapid during rainfall and snowmelt events creating frequent flooding in streams. These floods produce high-energy water flows that frequently erode stream channels compounding the problem of mass waste erosion on adjacent slopes.

Undoubtedly some of this rapid erosion occurred prior to European settlement, but there were factors in the forested landscape that buffered runoff and erosion in streams. After European settlement, and the disturbance that came with it, much of this buffering was diminished, resulting in increased erosion rates.

Forest Cover

Keeping in mind this characterization of the surficial geology and the effects it has on stream erosion processes, the following is a simplified description of what pre-European forest conditions were like in the clay plain. This description also includes changes that occurred in forest cover, what forest cover conditions are today, and finally the impacts these changes have had on forest hydrology in the clay plain.

Based on survey information (Finley et.al. 1976) the pre-European forest cover on the clay plain was predominantly coniferous. To the east of the Douglas/Bayfield county line and continuing to the eastern extent of the clay plain there was an increase of northern hardwood species associated with this coniferous forest. White pine was the predominant overstory species in number and stature. White spruce and balsam fir created a dense sub-overstory canopy beneath the white pine in the western clay plain. To the east sugar maple, yellow birch, and hemlock were mixed with the fir and spruce. White birch and aspen were common associates throughout the clay plain. Their presence was associated with natural disturbance in the forest.

At a smaller scale of forest cover, in ravines vs. uplands, there were some interesting differences in forest composition. More mature forest conditions, predominance of larger diameter white pine associated with dense spruce-fir and cedar trees occurred in ravines. Uplands had a more even size class distribution of white pine. Also white birch and aspen were more common in the upland forest (Koch, 1980). One conclusion to be drawn from this difference in cover type is that natural disturbance was more common in the uplands and ravines provided protection from disturbance. Later succession forest conditions in ravines likely had well-developed vertical structure of live standing and dead downed woody debris.

Forest floors associated with these conifer forest cover types accumulated organic matter and a fairly thick duff surface soil layer existed. This duff layer along with large volumes of downed woody debris were capable of retaining large volumes of water that would otherwise runoff the clay textured surface soil.

Although natural disturbance information is not well documented for the pre-European clay plain forest, the primary disturbance forces were likely wind and fire. Wind storms could easily blow down areas of shallow rooted fir and spruce in the uplands. Ravines were somewhat protected from the wind. The downed conifer trees provided fuel for occasional fires, most likely started by lightening. These fires were seldom severe, and with fairly high moisture conditions in the standing forest, burned through the blow down and than were extinguished by the moist conditions in the adjacent standing forest. Again ravines were very moist and resistant to fire disturbance.

When Europeans arrived they found a dense forest cover, particularly along waterways. Conditions within this dense forest cover inhibited human passage. To them the forest was a hindrance to be overcome.

Initially harvesting the white pine was the focus. Because roads were few and poor at best, waterways were the thoroughfare to move logs to sawmills. Waterways were dammed and large volumes of logs were floated down stream to Lake Superior. The energy and force resulting from this activity drastically effected erosion along waterways. Also, log drives removed most of the large natural woody debris that had been deposited over hundreds of years. Removal of the woody debris deteriorated the structural features of the streams, reducing habitat for organisms and negatively impacting their hydrological character. Evidence of damage caused by log drives is still visible today.

Harvesting was soon followed by the desire to clear land for farming. The relatively stone-free clay soil offered great opportunity for farming. Remaining forest cover in areas to be farmed were removed. This land clearing usually involved burning of the unwanted forest debris.

While it is often thought that the harvesting of white pine is what left the clay plain landscape so barren, it was actually fire that so completely opened up the landscape. Most of these fires were man caused, likely associated with land clearing operations for agriculture. With already large volumes of conifer slash left on the forest from harvesting and land clearing fires were much larger and more intense than natural fires that occurred during pre-European times.

Where land wasn't farmed, burned over areas offered great opportunity for pioneer species like aspen and paper birch to become established. Conifers did remain on the landscape but due to their flammability much of the cover type was consumed by fire. Most of the remaining conifer cover was likely confined to the ravines.

Harvesting, land clearing for agriculture and fire were the main three man caused disturbances that removed almost all forest cover indicative of pre-European settlement. Of these disturbances fire produced the greatest change. Log drives down streams scarred channels initiating large erosion areas still evident today. Upland retention of rainfall and snowmelt water runoff was substantially reduced. Energy produced by increased runoff flowing through the badly scarred waterways produced high stream erosion rates.

Artificial Drainage
One additional man-caused disturbance that went beyond changing forest cover was changing the shape of the landscape surface itself. Artificial drainage associated with agricultural fields and road infrastructure moves rain and snow-melt water, already rapidly running off the exposed clay soil, at an even faster rate off the uplands. This expedited delivery to streams creates even greater energy available to erode stream banks and adjacent slopes. While impacts from disturbance to the pre-European forest and stabilization of stream riparian areas is slowly occurring with time through natural forest succession, artificial drainage is maintained, and likely has a great impact on modern day flooding of south shore streams.

Summary
Similar summary of these events and conclusions of their impacts on the red clay plain are presented in the 1998 publication "Erosion and Sedimentation in the Nemadji River basin" (NRCS, 1998). Although there are some differences in the landscape character of the Nemadji River basin and part of the clay plain to the east this publication's conclusions and strategies for management are very applicable. The Nemadji River basin study serves as an excellent template for remedial management of the hydrologic conditions in the clay plain in general. Any future work to improve hydrologic conditions in the clay plain should begin with a review of this document.

Michigan

Table 6-17 lists the 12 streams in the Michigan portion of the Lake Superior basin that are not meeting designated uses.

Elevated copper concentrations from copper ore tailings are problems for a number of streams (Hammell Creek, Kearsarge Creek, Scales Creek and Traprock River) in Houghton County. Habitat loss to sedimentation has also been a problem in this watershed. The west and east branches of the Eagle River also have high levels of copper.

Table 6-17 Michigan non-attainment streams in the Lake Superior basin (Michigan Dept. of Environmental Quality 1998)

Stream	Length (km)	Problem	Source
Adventure Creek	1	Macroinvertebrate community rated poor	Obstruction of stream channel resulted in severe erosion and sedimentation
Mineral River	1	Macroinvertebrate community rated poor; total dissolved solids	
Bluff Creek	21	Fish community rated poor.	Sedimentation and bank erosion related to extreme flow fluctuations
Kearsarge Creek	6	Copper; macroinvertebrate	Copper ore tailings

Table 6-17 Michigan non-attainment streams in the Lake Superior basin (Michigan Dept. of Environmental Quality 1998)

Stream	Length (km)	Problem	Source
		community rated poor.	
Scales Creek	418	Copper; macroinvertebrate community rated poor.	Copper ore tailings
St. Louis Creek	1	CSO, bacterial slimes, pathogens.	
Hammell Creek-Osceola Mine Discharge	1	Mercury and copper	Copper ore tailings
Trap Rock River	10	Copper	Copper ore tailings
Eagle River, E. Br.	10	Copper	
Eagle River, W. Br.	4	Copper; macroinvertebrate community rated poor	
Carp River	47	Mercury	
Whetstone Creek	3	Periodic fish kills.	Urban stormwater runoff, severe sedimentation and discharges of suspected toxic substances
Carp Creek	18	Mercury.	

6.1.9 Inland Lakes

The Lake Superior basin has almost 7000 inland lakes, covering over 10,000 square kilometers. These lakes range in size from less than 1 ha to Lake Nipigon at 448,000 ha (Table 6-18). Inland lakes are an important link in the hydrological cycle since much of the water that enters Lake Superior flows through lakes. They contribute to the diversity of aquatic habitats in the basin.

Most lakes are found on the shallow soils of the Precambrian Shield in Ontario and northern Minnesota (Figure 6-44). Another concentration of lakes is in the Presque Ile River watershed in Vilas County Wisconsin and Gogebic County, Michigan.

Secchi depth is a measure of lake transparency, reflecting the amount of suspended material and algae in the water. Secchi measurements are available for over 700 lakes in the basin. Over half the lakes are in the 1 – 3 m Secchi depth range (Figure 6-45). Inland lake transparency is recommended as an indicator of ecosystem health by the Lake Superior Binational Program (1998). Unpolluted lakes show a range of transparencies due to naturally-occurring differences in nutrient availability and turbidity. However, changes in Secchi transparency can indicate a change in the trophic state of a lake due to pollution.

Inland lakes in Ontario and the North Shore area of Minnesota tend to be cool, clear, and low in dissolved solids and nutrients (MPCA 1997). South of Lake Superior, inland lakes tend to be warmer and richer. The number of oligotrophic (nutrient-poor) lakes ranges from 15 to 54 percent in Michigan, Minnesota, and Ontario, but methods of measuring trophic status differ between Ontario and the U.S., and comparisons are difficult (Figure 6-46).

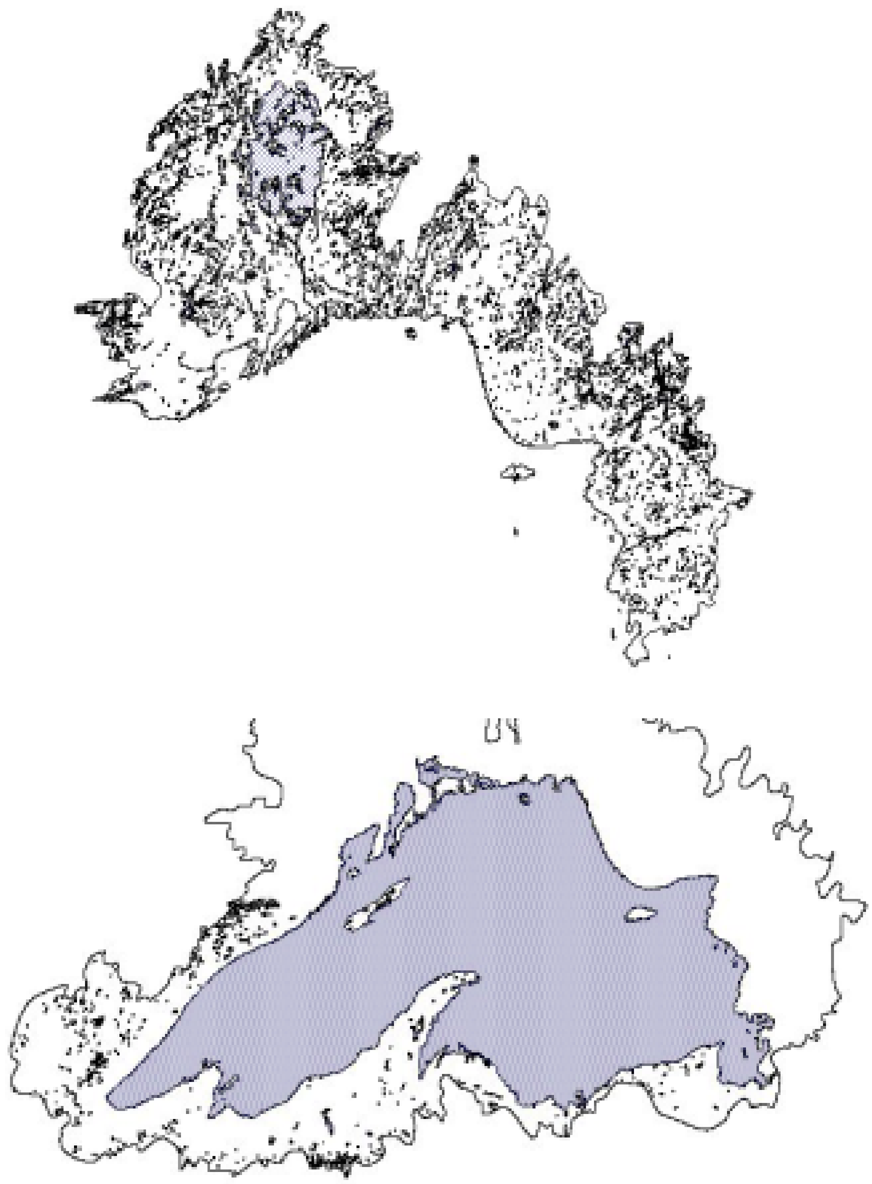
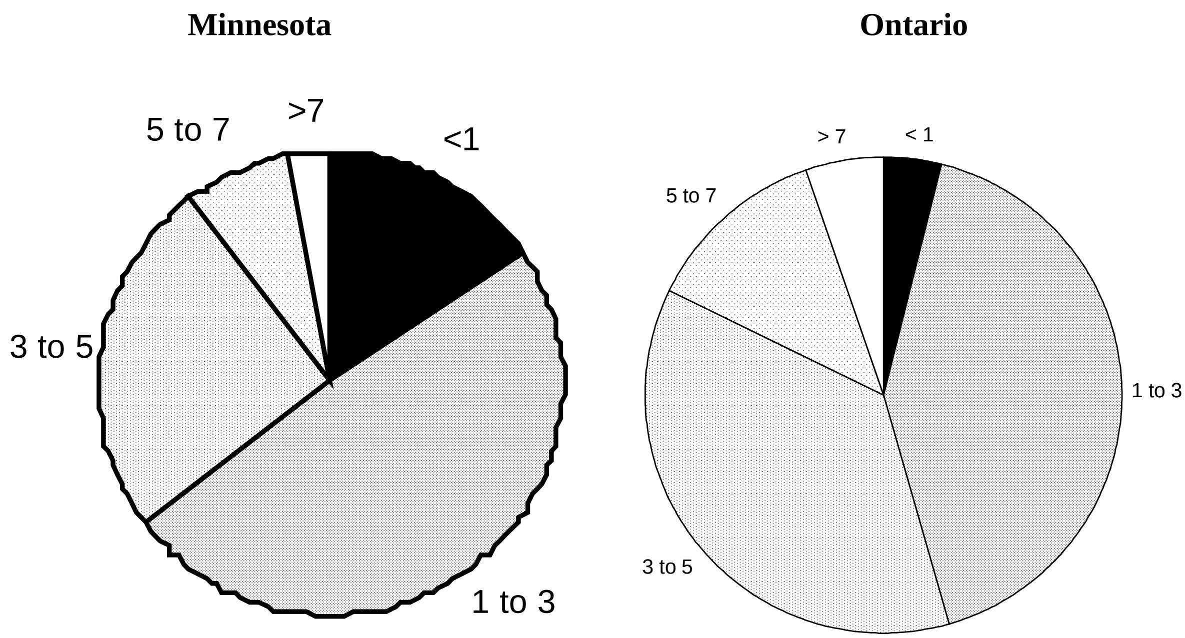


Figure 6-44. Inland Lakes of the Lake Superior basin (Lake Superior Decision Support Systems and OMNR data)

Figure 6-45. Secchi depth (m) for 1,128 Ontario and 147 Minnesota lakes within the basin (Ontario Ministry of Natural Resources and MPCA Data)



Fish communities in Ontario and Minnesota are dominated by cool and coldwater species (Figure 6-47). Oligotrophic lakes often support lake trout, lake herring and lake whitefish, but are relatively species-poor. About 100 lakes in the Minnesota North Shore support lake trout (Waters 1987). Some lakes in the southern part of the basin provide warmer and more nutrient-rich habitat than Lake Superior. Warmwater species, such as sunfishes and catfishes, dominate the fish community.

Table 6-18 Major Inland Lakes in the Lake Superior Basin

Lake Name	Area (km^2)	Max. Depth (m)	Mean Depth (m)	Littoral Area (%)	Trophic Status*	Secchi Depth (m)
Lake Nipigon, ON	4,481	137	55		Oligotrophic	6.5
Dog Lake (Thunder Bay), ON	148	117	30	29	Oligotrophic	2.5
Onaman Lake, ON	108	19	2	97	Eutrophic	1
White Otter Lake, ON	83	56	22	91	Oligotrophic	4.8
White Lake, ON	59	49	9	54	Eutrophic	2.7
Shebandowan Lake, ON	59	38	8		Oligotrophic	2.9
Lake Gogebic, MI	52					
Dog Lake, (Wawa) ON	52	75				4.4
Black Sturgeon Lake, ON	48	49	12	23	Oligotrophic	2.5
Esnagi Lake, ON	46	22	5	47	Eutrophic	3.7
Windermere Lake, ON	38	30	8		Oligotrophic	4.8
Wabatongushi Lake, ON	38	53	7	59	Eutrophic	2.9
Obonga Lake, ON	36	72	17		Oligotrophic	3
Muskeg Lake, ON	35	12	5	66	Eutrophic	2
Island Reservoir, MN	34	22	-		Eutrophic	2
Arrow Lake, ON	33	55	18	23	Oligotrophic	4.7
Manitowik Lake, ON	31	119	38	19	Oligotrophic	3.7
McKay Lake, ON	31	49	9	62	Eutrophic	4
Greenwater Lake, ON	31	55	18	14	Oligotrophic	4
Whitefish Lake (Th. Bay), ON	30	6	2	100	Eutrophic	3
Forgan Lake, ON	30	44	13	35	Mesotrophic	4
Cedar Lake, ON	29	15	6	100	Eutrophic	2.1
Cliff Lake, ON	27	34	9	50	Eutrophic	4.3
Kagiano Lake, ON	24					2
Barbara Lake, ON	24	56	10		Oligotrophic	3
Kashabowie Lake, ON	23	35	7	58	Oligotrophic	2.6
Whiteface Reservoir, MN	23	10			Eutrophic	1.2
Holinshead Lake, ON	23	17	5		Oligotrophic	2
Athelstane Lake, ON	18	33	9		Oligotrophic	3.4
Garden Lake, ON	18	22	7		Oligotrophic	2
Boulder Lake, MN	18	29		74		2.1
Wabinosh Lake, ON	18	39	11		Oligotrophic	5
Whitefish Lake (Wawa), ON	18	55	15	33	Oligotrophic	3.1
Wildgoose Lake, ON	17	16	4		Eutrophic	4
Roslyn Lake, ON	17	45	10		Oligotrophic	4
Loch Lomond, ON	17	71	21		Oligotrophic	4

Table 6-18 Major Inland Lakes in the Lake Superior Basin

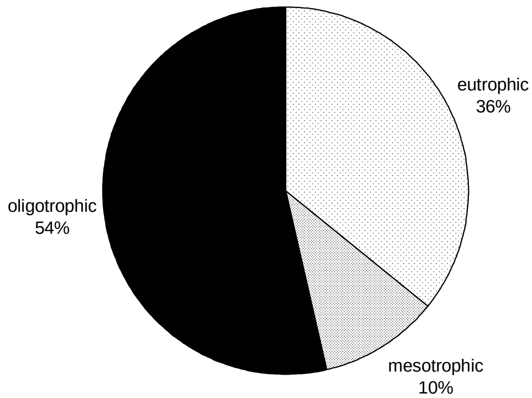
Lake Name	Area (km^2)	Max. Depth (m)	Mean Depth (m)	Littoral Area (%)	Trophic Status*	Secchi Depth (m)
Brule Lake, MN	17	18		34	Oligotrophic	4.9
Helen Lake, ON	16	61	13		Mesotrophic	3

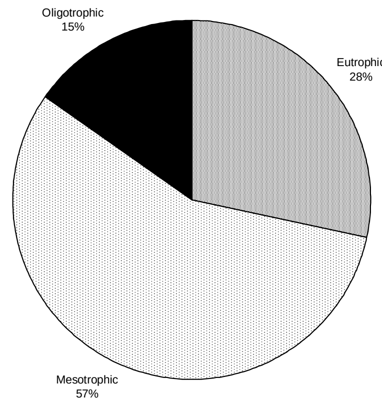
*Trophic status for Ontario lakes is based on morphoedaphic Index (MEI). MEI values between 6 and 7 are mesotrophic, higher are eutrophic, lower are oligotrophic (Leach and Herron 1996). Trophic status for U.S. lakes are determined using the Carlson method.

Table 6-19 Inland lakes in the Lake Superior basin

(derived from OMNR and NRRI data)

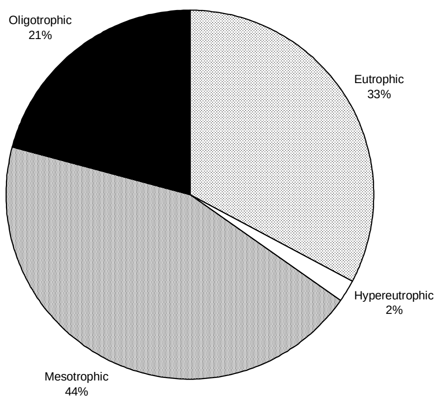
	n	% > 10 ha	Shoreline Length (km)	Total Area (km^2)	Mean Area (km^2)
Ontario					
Lakes and Reservoirs	5049	95	27019	9277	2.0
Michigan					
Lakes	668	67	1842	361	0.5
Reservoirs	36	78	248	91	2.5
Minnesota					
Lakes	873	71	2357	375	0.4
Reservoirs	38	76	412	101	2.7
Wisconsin					
Lakes	272	70	683	104	0.4
Reservoirs	9	78	45	12	1.4





Ontario

Michigan



Minnesota

Figure 6-46. Trophic status of inland lakes in the Lake Superior basin

(a) Ontario (n= 516), (b) Michigan (n = 78) (c) Minnesota (n = 208) (data from Ontario Ministry of Natural Resources, Michigan Dept. of Environmental Quality, and Minnesota Pollution Control Agency data data)

Ontario

Ontario lake survey data are available from 1,251 lakes within the basin, but there are thousands of unsurveyed lakes. Surveyed lakes tend to be large, accessible and support sport fishes. Much of the lake survey data is over 20 years old.

Two lakes in the basin, Lim and Mose lakes, are severely degraded by mine effluent (OME 1992). Numerous other lakes have fish consumption advisories – primarily due to mercury levels. Ontario does not have an on-going lake water quality program.

Dams have altered water level regimes on many of the larger inland lakes. Dams were built to improve navigation or for historical log drives and many of these dams persist today. Increased water levels resulted in flooding the original shoreline and disruption of the natural flooding-drawdown cycle.

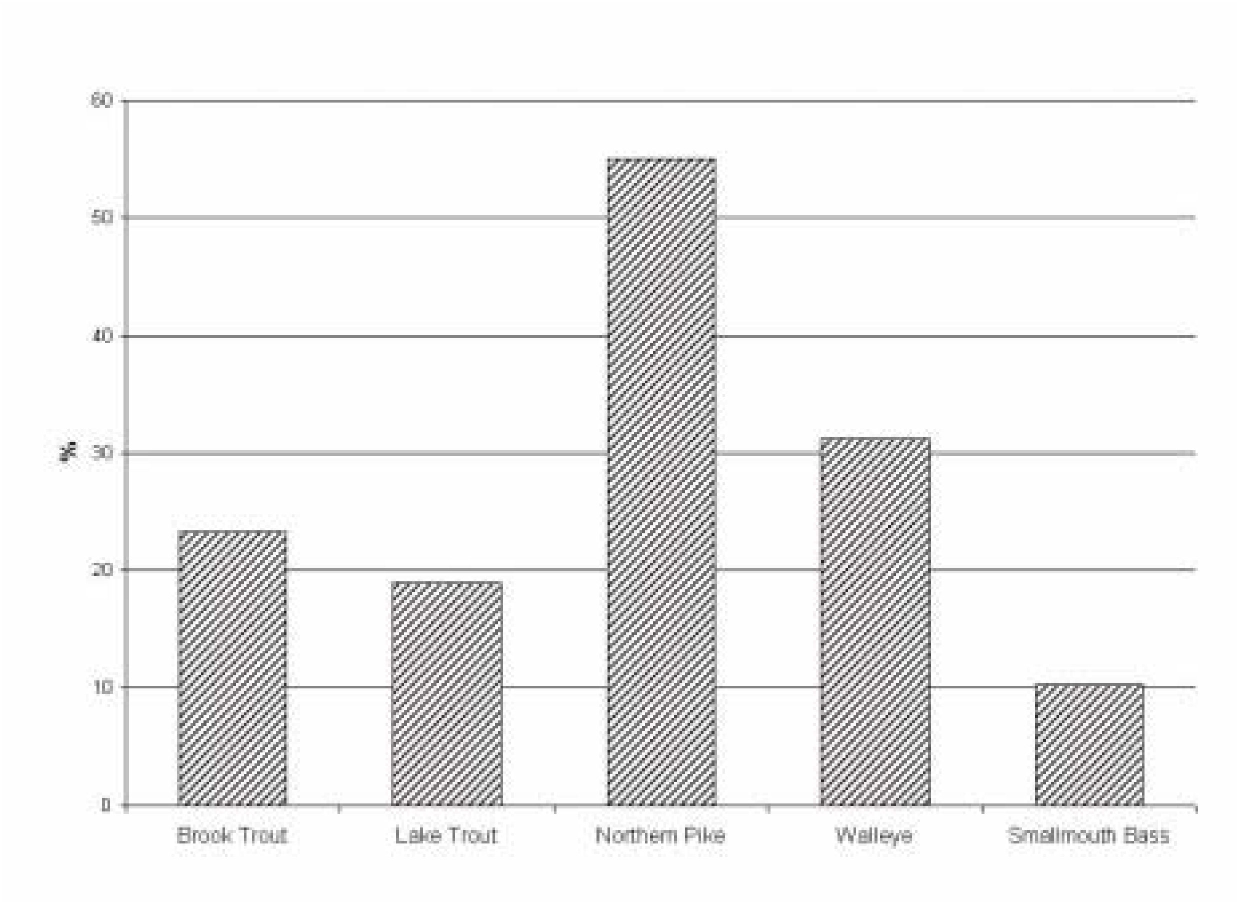


Figure 6-47. Frequency of occurrence of major sport fish species in 612 Ontario lakes in the Lake Superior basin
(**Ontario Ministry of Natural Resources data)**

Most inland lakes in Ontario are within forest management units where logging takes place. Potential impacts of logging and associated road construction include increased sedimentation, increased water temperatures, changes in water yield and availability of woody debris (OMNR 1988). Provincial policy requires reserves of uncut forest to be left around lakes. Reserve widths depending on shoreline slope and fisheries values (wider for cold water lakes and steeper slopes). A pilot study investigating the habitat impacts of logging on lakes is underway (Steedman personal communication), but widespread monitoring is not done.

Wisconsin

Most lakes in the Wisconsin basin have basic descriptive data. A document summarizing the status of inland lakes in the Lake Superior basin is in preparation (Turville-Heitz 1999).

Twenty six lakes in Wisconsin are listed as having “Impaired Waters” (Turville-Heitz 1999), all related to mercury levels in fish (Table 6-20).

Five Wisconsin lakes in the basin were identified as priority sites from a biodiversity perspective (Epstein and others 1997). These are Anodanta Lake, Bad River Slough, Hoodoo Lake, Rush Lake, and Smith Lake. Most of these lakes have rich invertebrate communities or support rare invertebrate species.

Table 6-20 Wisconsin lakes in the Lake Superior basin with impaired waters (Turville-Heitz 1999)

Lake	Problem
Amnicon Lake	Mercury/fish advisory/atmospheric deposition
Annabelle Lake	“
Bear Lake	“
Bladder Lake	“
Cisco Lake	“
Diamond Lake	“
English Lake	“
Forest Lake	“
Galilee Lake	“
Gile Flowage	“
Island Lake	“
Long Lake	“
Long Lake	“
Lynx Lake	“
Mineral Lake	“
Oxbow Lake	“
Palmer Lake	“

Table 6-20 Wisconsin lakes in the Lake Superior basin with impaired waters (Turville-Heitz 1999)

Lake	Problem
Perch Lake	“
Pike Chain of Lakes	“
Potter Lake	“
Siskiwit Lake	“
Spider Lake	“
Spillerberg Lake	“
Tahkodah Lake	“
Three Lake	“
West Twin Lake	“

Michigan

Ten lakes in the basin are listed as “non-attainment”, mostly due to fish consumption advisories for mercury (Table 6-21). Torch Lake, in Houghton County, was the receiving water for copper ore tailings, and other contaminants. Sediments have high levels of arsenic, copper and other metals and benthic invertebrate communities are impaired (MDEQ 1998).

Table 6-21 Michigan non-attainment lakes in the Lake Superior basin (Michigan Dept. of Environmental Quality 1998)

Lake	Problem
Chaney Lake	FCA-mercury
Marion Lake	Mercury Lake
Langford Lake	FCA – mercury
Six Mile Lake	Mercury Lake
Torch Lake	Macroinvertebrate community rated poor; WQS exceedances for copper
Perch Lake	Mercury Lake
Lake Independence	Mercury Lake
Deer Lake	FCA-mercury
Nawakwa Lake	Mercury Lake
Pike Lake	Mercury Lake

Minnesota

There are five major hydroelectric dams on the St. Louis River system creating two of the largest impoundments in the basin: Island Reservoir and Whiteface Reservoir (MPCA 1996). These are headwater reservoirs that store water during the spring run off and release it to augment low flows at other times of the year. Other impoundments (Two Rivers Reservoir and Whitewater Reservoir) are used to for mine processing water and recreation.

Water quality monitoring in Minnesota lakes is done by the Minnesota Pollution Control Agency. Emphasis has shifted recently, away from point-source influenced lakes to volunteer monitoring (approximately 30 lakes in the basin – secchi depth, recreational suitability) and reference lake monitoring (water quality, land use in the watershed) (MPCA 1997).

Water quality is generally quite good (MPCA 1996). Thompson and Fond du Lac reservoirs have significantly contaminated sediments (MPCA 1996). 94 percent of inland lakes tested (137/146) have fish consumption advisories, due to mercury levels (n = 133), PCB levels (n = 1) or both (n = 3) (MPCA 1996).

Minnesota, Michigan and Wisconsin have volunteer lake monitoring programs (Lake Superior Binational Program 1998).

Summary

The status of habitat in inland lakes in the Lake Superior basin is generally very good. Gross habitat impairment from point sources has occurred in only a few lakes. More subtle changes in lake habitat, such as eutrophication, sedimentation and warming, due to land use changes are more difficult to detect and measure, as are the impacts of non-point source pollutants.

6.1.10 Rare and Declining Species

The species discussed in this section are considered to be rare or declining in at least one of the states/provinces in the basin. Species can be listed at the federal, provincial, or state levels.

The U.S. federal categories are as follows:

> **Endangered** - The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.
>
> **Threatened** - The classification provided to an animal or plant likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
>
> **Species of Concern** - "Species of concern" is an informal term that refers to those species which might be in need of concentrated conservation actions. Such conservation actions vary depending on the health of the populations and degree and types of threats. At one extreme, there may only need to be periodic monitoring of populations and threats to the species and its habitat. At the other extreme, a species may need to be listed as a Federal threatened or endangered species. Species of concern receive no legal protection and the use of the term does not necessarily mean that the species will eventually be proposed for listing as a threatened or endangered species.

The Canadian federal categories are:

> **Endangered:** A species facing imminent extirpation or extinction.
> **Threatened:** A species likely to become endangered if limiting factors are not reversed.
> **Vulnerable :** A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.

Ontario, Minnesota, Wisconsin, and Michigan have slightly differing definitions for the state / provincial level listings, but are similar in intent to the federal listings.

6.1.10.1 Bald Eagle

The bald eagle is threatened in Michigan. A state-wide survey is conducted each year to monitor breeding success. The state goal is to have 300 nesting pairs. Between 1976 and 1999, a total of 130 different breeding areas were active within the Baxin, including Isle Royale (not all are occupied in any given year). The number of breeding areas has increased over the last 20 years. In 1999, 89 breeding areas were occupied by adult pairs (Dave Best personal communication). The Michigan Department of Natural Resources also conducts mid-winter bald eagle surveys. In 1999, there were 235 eagles reported in the Upper Peninsula. The status of eagle habitat in the basin appears to be stable (Ray Rustem personal communication).

Since the ban of DDT in the late 1960’s, Bald Eagle numbers have increased throughout their range. In 1999 they were removed from the U.S. Endangered Species List.

Within the Lake Superior basin, eagle numbers appear to have followed the same pattern of decline and recovery, but little specific data are available. Reproductive rates of eagles nesting along the Lake Superior shoreline are significantly lower than those nesting on inland lakes (1.0 vs. 1.3 young per active territory) (Dykstra and others 1998). Depressed reproduction rate was likely caused by low food availability.

Nesting habitat for Bald Eagles includes trees that at are large enough to hold their massive nests. Red and white pine supercanopy trees are preferred in Minnesota (Coffin and Phannmuller 1988) Many of these nests are close to lakes or rivers, areas where the eagles scavenge for fish.

Figure 6-48 shows an assessment of bald eagle nesting habitat based on percentage of forested area and proximity to the shoreline, potential human disturbance, shoreline irregularity, available foraging habitat, and availablity of perching and nesting trees (Bowerman 1993).

Wisconsin

About 1500 bald eagle pairs nest in Minnesota and Wisconsin, but less than 5 percent of these are along the Lake Superior coast (Bill Bowerman, personal communication). The number of occupied territories along the Wisconsin Lake Superior coastline tripled between 1983 and 1991 (Meyer 1992).

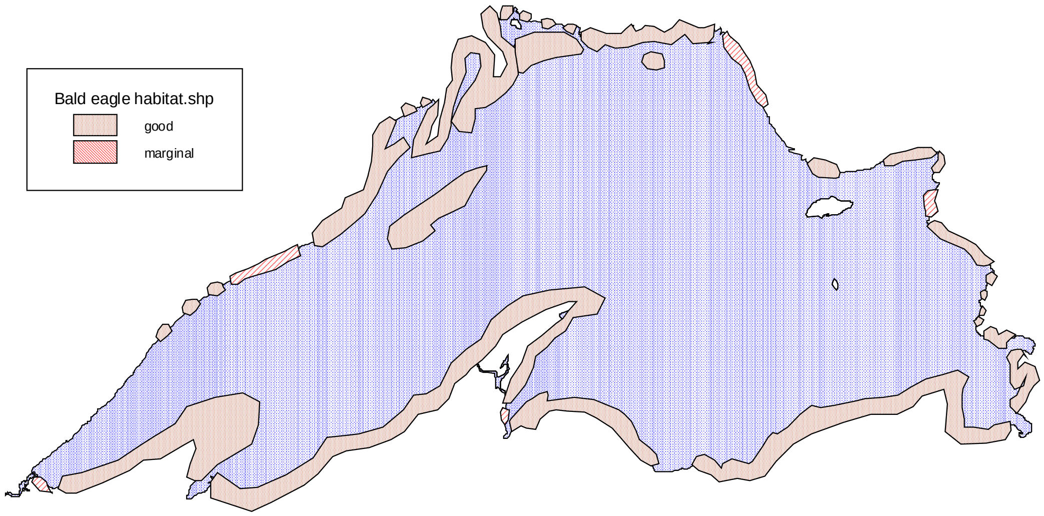


Figure 6-48. Potential bald eagle nesting habitat within 1.6 km of Lake Superior Unshaded areas are considered unsuitable (Bowerman 1993)

Nesting habit is considered good to excellent within the Lake Superior basin. Housing construction is occurring at a record pace along lakeshores and riparian lands in northern Wisconsin and it is not known what this threat has on eagles nesting. Contaminant levels have dramatically declined in recent years and is no longer considered a threat to reproduction. Productivity of nesting eagles along the Lake Superior coast fluctuates from year to year depending on ice conditions and prey availability (Mike Meyer, Wisconsin DNR personal communication).

On the Apostle Islands, there has been a fairly stable population of about five pairs for the last few years (Julie Van Stappen, Apostle Islands N.L. per. comm.). Food shortage appears to limit population growth since there are many adequate nesting trees available and blood analysis indicates that contaminants are probably not impairing survivorship or reproduction. Spring ice packs restrict access to fish and the absence of deer on the islands limits late winter food availability.

Bald Eagles were delisted in Wisconsin in 1998. There have been annual surveys since 1985 and the future of these surveys is in doubt due to declining funds from the Adopt an Eagle Nest Fund.

Minnesota

The Minnesota population of Bald Eagles has increased dramatically since the 1970's and is now estimated at about 700 pairs. The last statewide survey was conducted in 1995, the same year that the birds were delisted. Based on current information (1999) in the Minnesota Heritage data, there are 41 eagle nests located in the Lake Superior basin. Most of these nests are in the interior away from Lake Superior (Maya Hamady, personal communication).

Habitat availability is probably the main factor limiting the number of eagles. Lake Superior probably offers poor foraging opportunities compared to inland lakes and the landscapes that drain into Lake Superior lack inland lakes.

Michigan

The bald eagle is threatened in Michigan. A state-wide survey is conducted each year to monitor breeding success. The State goal is to have 300 nesting pairs. The 1997 survey located 298 nests, of which 166 nest were in the Upper Peninsula. An estimate for the Lake Superior basin was not available and will be included in the final habitat report. The Michigan Department of Natural Resources also conducts mid-winter bald eagle surveys. In 1999, there were 235 eagles reported in the Upper Peninsula. The status of eagle habitat in the basin appears to be stable (Ray Rustem, Supervisor of the Natural Heritage Unit, Wildlife Division, MI DNR).

Ontario

In Ontario, bald eagles are Endangered. The number of eagle nests along the north shore has been fairly stable for the last few years, although new nests are established as old ones are abandoned (Foster and others 1999).

In the Thunder Bay District, most of the larger inland lakes have established nesting pairs and there are a few nests along the Lake Superior coastline. There have been no recent surveys, but the population probably has not changed in the past few years (Steve Scholton, Thunder Bay District OMNR, personal communication).

The Lake Superior shore between Black Bay and Pukaskwa Park appears to consists of good habitat. Population has been fairly stable with 15 – 16 nests. Spring runs of trout, salmon and suckers are common and food supply should not be a limiting factor. Lake Nipigon has not been surveyed in a few years, but numbers have probably not changed dramatically in recent decades (Rosemary Hartley, Nipigon District OMNR, personal communication).

Seven active nests are in the White River to Montreal River portion of the watershed. Numbers appear to be growing and habitat does not appear to be a limiting factor (Joel Cooper Wawa District OMNR, personal communication).

The shoreline south of the Montreal River to Sault Ste. Marie has fewer than ten active nests. Habitat is adequate and there is room for more pairs (Jim Saunders, Sault Ste. Marie District ONMR, personal communication).

Eagle nest sites are recognised in timber management and guidelines for their protection are applied in Ontario.

6.1.10.2 Peregrine Falcon

Peregrine falcon populations declined across North America due nesting failure resulting from to bioaccumulation of DDT and its metabolites. They disappeared as a nesting species from most of the Lake Superior basin by the mid 1960’s.

Following the ban of DDT, efforts were initiated to re-establish peregrine falcons as a breeding species within the Lake Superior basin. Between 1988 and 1996, Minnesota hacked 40 young peregrines on the North Shore, Michigan released 50 young birds on Isle Royale, and 46 bird in the Upper Peninsula. Ontario hacked 87 birds in the Thunder Bay area and 38 near Sault Ste Marie (Bud Tordoff, Ted Armstrong, personal communication). These efforts have succeeded in establishing nesting pairs (Table 6-22). In the Lake Superior basin, 90 young peregrines were banded in Ontario and 59 young in Minnesota between 1996-1999.

The peregrine falcon was removed from the United States Endangered Species List in 1999. Michigan and Wisconsin list peregrines as Endangered, while Minnesota lists peregrines as Threatened. In Canada, peregrines are classified as Threatened at the federal level, but are considered Endangered in Ontario.

Peregrines nest on cliff ledges, often adjacent to water, but inland sites are also used. Man-made structures such as buildings, bridges, smokestacks, and quarries, are sometimes used. The best peregrine habitat in the Lake Superior basin is associated with the numerous large cliffs between the Pigeon River and the Nipigon River in Ontario (Ratcliff 1997, 1998, 1999). Almost half of the nests in the basin are in this area.

Current and potential peregrine territories are shown in Figure 6-49. “Potential” territories include historical nest sites that are not currently used and other cliffs which have been surveyed and assessed as being suitable (Ratcliff 1997, 1998, 1999; Bud Tordoff, personal communication). Due to the large amount of potential habitat available, and inaccessibility of most of this area, the estimate is a minimum number.

Overall, the status of peregrine falcon habitat is stable or increasing. Manmade structures increase the number of potential nest site in the Lake Superior basin over historical levels.

Ontario

In 1998, there were 17 known territories occupied by pairs and three territories held by a single birds and in 1999, 12 territorial pairs and six single bird territories were located in the Lake Superior basin. In addition, there are at least six confirmed and suspected historical sites that probably could support pairs (Ratcliff, 1997, 1998, 1999) (Table 6-22).

Minnesota

Historically, peregrines nested on five cliff sites along the northshore. As of 1998, there were eight pairs of peregrines along the North Shore of which, two used bridges within the city of Duluth and two nests were on mining structures (Bud Tordoff personal communication). There is potential for four more cliff nesting sites (Bud Tordoff, personal communication). Annual surveys are conducted throughout Minnesota checking both cliff sites and man-made structures.

Wisconsin

The small cliffs within the Wisconsin portion of the Lake Superior basin are not suitable for breeding peregrines. Except for man-made structures, habitat is very limited (Bud Tordoff and Sumner Matteson personal communication). There are no historical records for this area and any future nesting sites will probably be on man-made structures. Wisconsin conducts annual surveys for peregrines, and to date all nesting sites have been on man-made structures outside the Lake Superior basin.

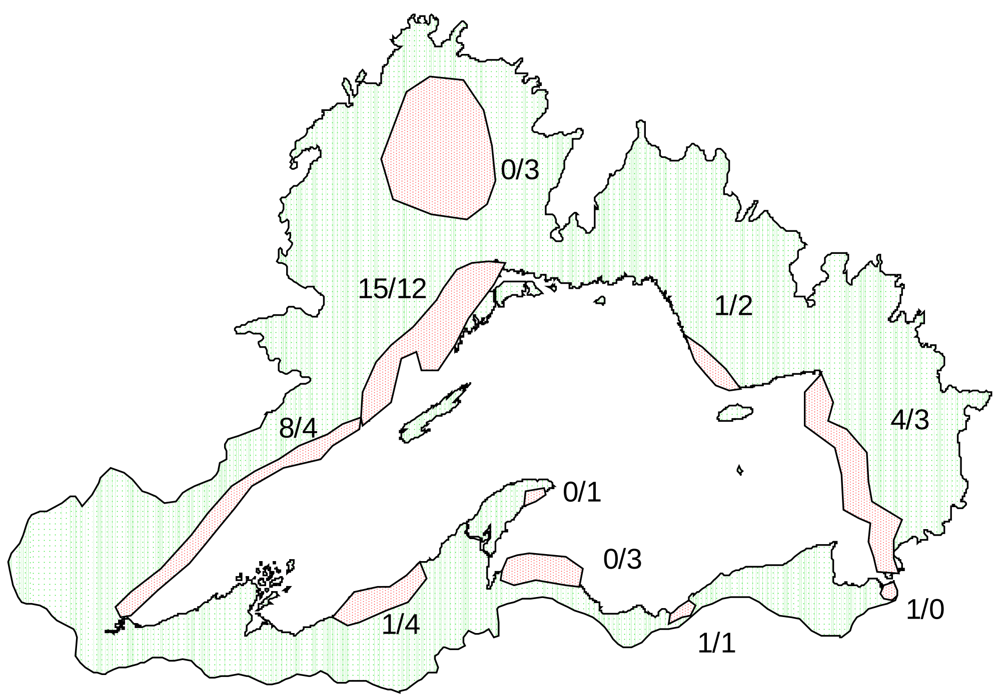


Figure 6-49. Peregrine Falcon Habitat in the Lake Superior basin Numbers of current and additional potential territories are given (current number/potential number)

Michigan

Historically, peregrines nested at 13 cliff sites in the Upper Peninsula. There are four known cliff sites where peregrines nested during the 1990's (Bud Tordoff, personal communication), and in 1999 birds nested at two of these sites (Joe Rodgers, personal communication). A pair was also established but unsuccessful at the International Bridge at Sault Ste. Marie. Annual surveys for peregrines are conducted. There is good potential habitat it the Upper Peninsula (Joe Rodgers) (Table 6-22).

6.1.10.3 Piping Plover

Piping plover is classified as Endangered in Michigan, Wisconsin, Minnesota and Ontario and federally in both Canada and the U.S. (Great Lakes Population).

In the Great Lakes area, these birds historically nested on sandy and gravel beaches and sparsely-vegetated shorelines with gravel or pebbly mud substrate. At Duluth, they nested on dredge-spoil islands (Coffin and Pfannmuller 1988). Beaches separated from the tree line by a wide dune system or slough offer the best habitat and wide beaches provide better habitat than narrow beaches (Lambert and Ratcliff 1979).

Table 6-22 Current and potential peregrine falcon territories in the Lake Superior basin

Location	Current Territories	Other Potential Territories
Ontario		
Pigeon River to Nipigon	15	12
Lake Nipigon	0	3
Pukaskwa to Michipicoten	1	2
Lake Superior P.P. to Sault Ste. Marie	4	3
Minnesota		
Northshore	6	4
Duluth	2	-
Wisconsin	-	-
Michigan		
Sault Ste. Marie	1	0
Porcupine Hills/Bergland	1	4
Pictured Rocks/ Grand Island	1	1
Bete Grise Bay	0	1
Huron Mountains/Champion	0	3
Total	**31**	**33**

Since the 1960s, piping plover populations have declined precipitously. Threats to habitat include high water levels (mid-summer storms), recreational uses, and all-terrain vehicles on beaches. Additional threats to plovers include increased gull populations and free running dogs on beaches. The quantity and quality of beach habitat is dynamic and influenced by fall and winter storms that erode and deposit sand and set back vegetation succession.

Ontario

There have been no documented reports of piping plovers nesting along the Lake Superior shoreline, although there is potential habitat Caribou Island (good), Agawa Bay (marginal) and Beaver Rock (marginal) (Heyens 1996). Also, the mouth of the Pic River should be considered as good habitat. There are no annual surveys for piping plovers on Lake Superior.

Minnesota

The Minnesota north shore has very limited Piping Plover habitat. Historically they nested at the Duluth Harbour on industrial lands; with six to eight pairs during the early 1970s and three pairs in 1985. However, development pressures, recreational use, increased Ring-billed Gull populations, and lack of management has limited this area for breeding (Coffin and Pfannmuller 1988). No plovers have nested here in the 1990s (Katie Haws, personal communication).

Wisconsin

Historically piping plovers nested in the 1950s at Barkers Island and Wisconsin Point in the Duluth - Superior Harbour. Piping Plovers did not nest along Lake Superior coastline for many years, but in 1998, one pair was successful (four young) at Long Island/Chequamegon Point (Sumner Matteson, personal communication). In 1999, one nesting pair and four other adults were observed here. The pair laid four eggs, hatched two young, but both young were killed by a mammalian predator. Surveys have been conducted each year since 1974. The habitat at Long Island has expanded due to lower water levels and the area could support 15 - 20 pairs (Sumner Matteson, personal communication).

Michigan

Michigan has most of the piping plover habitat on Lake Superior. There is excellent habitat in Luce, Alger and Chippewa Counties. Another site at Pictured Rocks National Seashore has marginal habitat.

The 1998 survey located seven nests at four sites: four nests at two sites near Grand Marais (Alger County), one nest at Vermillion (Luce County) and two nests at Weatherhogs Beach, (Chippewa County (Hinshaw 1998). Two historical nesting areas were surveyed with no nests found : Twelve Mile Beach, Pictured Rocks National Lakeshore, Alger Co. and Lake Superior State Forest Campground beach, Luce Co. The number of pairs is similar to those found in a 1979 survey (Lambert and Ratcliff 1979) (Table 6-23).

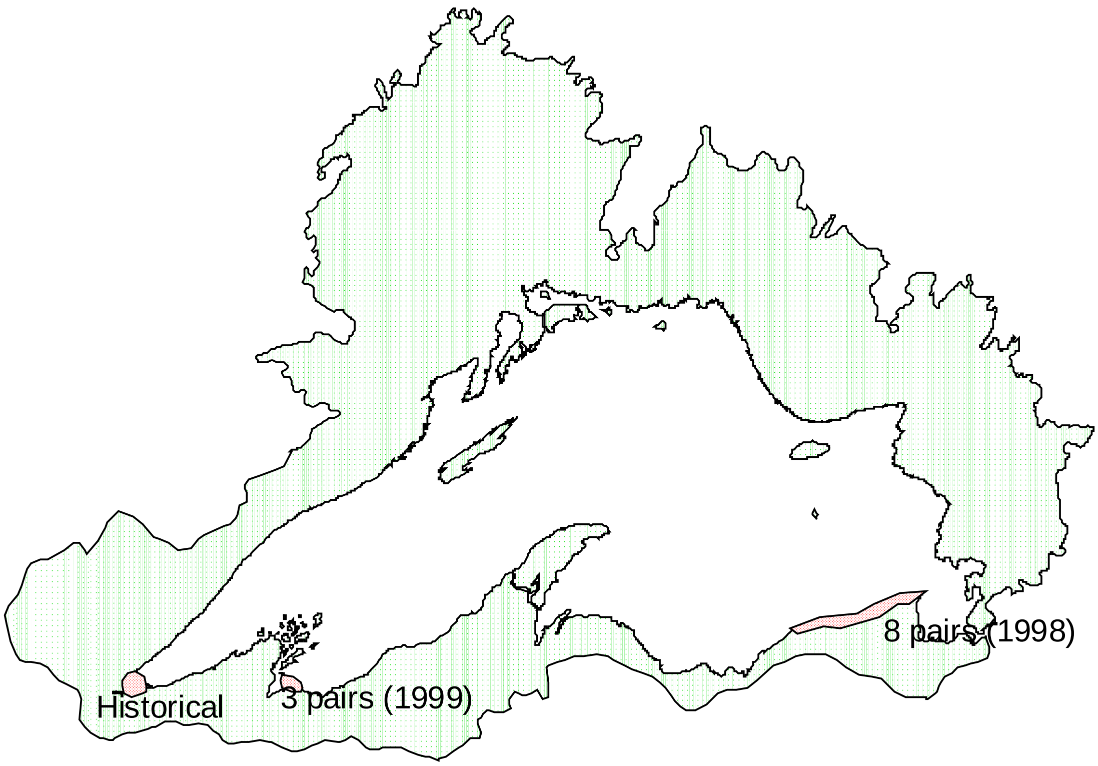


Figure 6-50. Piping plover habitat in the Lake Superior basin

Table 6-23 Piping plover survey results, Michigan (Lambert and Ratcliff 1979, Hinshaw 1998)

Location	Number of sites		Nests	
	1979	1998	1979	1998
Luce County	5	1	4	1
Alger County	1	2	3	4
Chippewa Co.	5	1	3	2

Habitat for plovers in Michigan at Vermillion is shifting eastward as vegetation encroaches on more westerly areas. The eastern portions of the beach are becoming narrower and more vegetated as well, resulting in a shift toward less suitable nesting habitat at this site. East of the Vermillion site, Weatherhogs Beach is widening and use of this area by plovers is increasing. Human disturbance of plover nests at Weatherhogs is more difficult to restrict than at Vermillion where the Whitefish Point Bird Observatory staff can restrict access and more closely monitor use of the beach. Enhancing habitat at Vermillion may be needed to retain it as a nesting area.

6.1.10.4 Common Tern and Caspian Tern

Common terns *(Sterna hirundo*) are Endangered in Wisconsin, Threatened in Michigan, Special Concern in Minnesota and unlisted in Ontario (Matteson 1988). Common terns nest at the St. Louis River estuary at the Duluth-Superior Harbor in Minnesota/Wisconsin. This colony declined 63 percent between 1977 to 1987 (Matteson 1988). In Wisconsin, there are 29 colony records on Lake Superior from the period between 1946 and 1987, most of these since the 1950's (Matteson 1988). In Michigan, common terns formerly nested along the Lake Superior coast in Chippewa County, but there are no recent nestings here (Hyde 1997). Common terns nest at several locations in the Ontario portion of the basin, but the north shore of Lake Superior constitutes a conspicuous distribution gap in the province (Blokpoel 1987). Low productivity of the lakes in the boreal shield in Ontario may be a limiting factor.

Caspian terns (*Sterna caspia*) are Endangered in Wisconsin, Threatened in Michigan and Vulnerable in Canada. This species was probably never common on Lake Superior (Hyde 1996). They nest at several locations in the Wisconsin part of the basin (WI DNR 1999a), but apparently don't nest in Minnesota. In Michigan, Caspian terns nest in several of the counties bordering Lake Superior, but are not known to nest within the basin itself (Hyde 1996). They are not known to nest in the Ontario basin (Austen and others 1994).

Chemical contamination, harvest for the millinery trade, and gull displacement contributed to the decline of these species. Important habitat includes small, sparsely vegetated islands or peninsulas for nesting. They will nest on man-made islands. Habitat related concerns include human disturbance at nesting sites, destruction of nesting habitat, and encroaching dense vegetation on nest sites. Rising water levels can flood nests and decrease available nesting habitat (Matteson 1988).

The objectives of the Wisconsin common tern recovery program are protecting nesting sites and establishing new colonies, population monitoring, evaluating chemical and habitat conditions and enhancing awareness (Matteson 1988).

6.1.10.5 Gray Wolf

The gray wolf was formerly distributed throughout the Lake Superior basin, but declined after the early 1800's due to extermination efforts in both Canada and the U.S. Wolf populations never declined to low levels in Ontario, but were extirpated in most of the U.S. portion of the basin by the early 1970s. Remnant populations persisted in northern Minnesota and on Isle Royale. Wolves were listed federally as Endangered in the US in 1967, offering them full protection. Wolf numbers and range increased in Minnesota and they repopulated Wisconsin and the Upper Peninsula of Michigan through immigration from Ontario and Minnesota. All three states now have breeding populations (Figure 6-51). A proposal to remove wolves from the federally Endangered list in the Great Lake States by the year 2001 is being considered by the U.S. Department of the Interior.

Wolf habitat consists of a relatively large land area with an adequate prey base. Major prey species are white-tailed deer in the southern part of the basin and moose in the north. Beaver and small mammals are important summer food. Habitat management to maintain or improve habitat for moose and deer is undertaken in all of the states and Ontario, mainly through timber management. Timber management can improve habitat for deer and moose and therefore have a positive effect on wolves by creating interspersion of mature forest with younger successional forest (Michigan Gray Wolf Recovery Team 1997, Wisconsin Wolf Advisory Committee 1999).

Wolves are most successful where there is limited human access (Michigan Gray Wolf Recovery Team 1997, Wisconsin Wolf Advisory Committee 1999). Road densities greater than 0.6 km / km^2 have been implicated in wolf declines due to collisions with vehicles and access by hunters and trappers. On the other hand, in areas of deep snow in Ontario, ploughed roads and packed snowmobile trails may make it easier for wolves to find and kill prey. Wolves can tolerate greater road density where humans don't kill or harass wolves (Michigan Gray Wolf Recovery Team 1997).

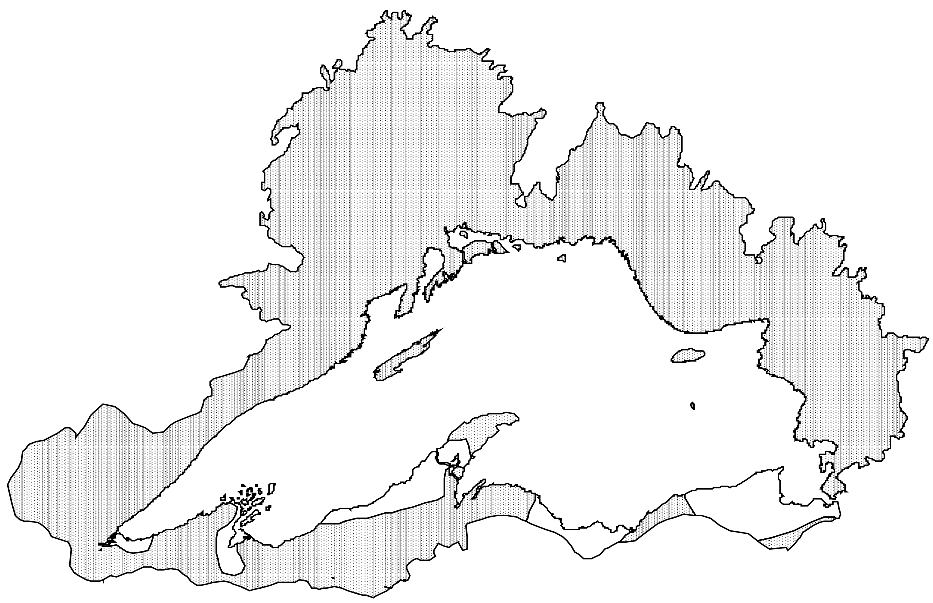


Figure 6-51. Wolf range in the Lake Superior basin C. 1997 (Michigan Gray Wolf Recovery Team 1997, Wydeven 1998, Coffin and Pfannumller 1988, Dobbyn 1994)

Human disturbance at den and rendezvous sites can cause abandonment of these areas. The area required for protection from disturbance has been estimated at approximately 0.05 percent of the pack's territory (13 ha for an average home range of 259 km^2) (Michigan Gray Wolf Recovery Team 1997).

Habitat corridors linking wolf populations may be important to allow wolves to move through landscapes fragmented by human activities (Michigan Gray Wolf Recovery Team 1997).

Wisconsin

Wolves returned to Wisconsin in the mid-1970s, and in 1975 was listed as Endangered. Management and recovery plans introduced in 1989 set goals of a population of 80 or more animals for more than three consecutive years (Wisconsin Wolf Advisory Committee 1999). In 1999, the wolf population reached 197 animals and had been at 80 or more animals since 1995. The Wisconsin Department of Natural Resources has now reclassified wolves as Threatened and is working on a management plan that will eventually delist the species. This plan would delist the wolf to a non-game species when the population reaches 250 or more animals across the state outside of First Nations Lands. A management goal of 350 is recommended.

Since 1979, the State has been monitoring the wolf population by radiocollaring one or two members of each pack. This method has been the most precise method of monitoring the population. Other survey methods include snow tracking and summer howling surveys.

Wolf habitat in Wisconsin has been assessed as primary or secondary (Mladenoff and others 1995). Based on computer models, primary habitat represents areas with a 50 percent or greater chance of supporting a wolf pack and secondary habitat represents areas with a 10 to 50 percent chance of supporting a wolf pack. Most of the primary and secondary habitat is in the northern third of the State, including much of the Lake Superior basin (Wisconsin Wolf Advisory Committee 1999).

Michigan

The Gray Wolf is considered Endangered in Michigan. Wolf populations have recovered from near extinction in the mid 1970s to at least 174 animals in 30 or more packs in 1998 - 99. This compares to 140 wolves located in 1997-98. In 1991, wolves reproduced in Michigan (other than on Isle Royale) for the first time in 40 years. All of the wolf packs are located in the Upper Peninsula (including much of the Lake Superior basin) and Isle Royale.

Monitoring for wolves is conducted by the Department of Natural Resources by using radio telemetry and snow track counts. There has also been a continuous monitoring program of wolves on Isle Royale since 1958. Two wolves first arrived on the island in the late 1940s and the population of wolves is dependant on the local moose population. As moose numbers fluctuate (500 - 2500) so have the wolf numbers fluctuated between 12 and 50 animals. Habitat supply analysis suggests that the Upper Peninsula could support over 800 wolves (Mladenoff and others 1995).

The Michigan Recovery Plan for the Gray Wolf will consider the animal recovered when there is a winter population of 200 animals for five consecutive years. At that time the wolf will be recommended for removal from the Michigan Endangered Species List.

Minnesota

In 1978, Minnesota reclassified the Gray Wolf from Endangered to Threatened and plans to delist the animal in 2000. The 1978 Grey Wolf Recover Plan set a population goal of 1,251 to 1,400 wolves by the year 2000. This goal was achieved when a statewide survey in 1989 estimated the population at 1,550 to 1,750 animals. Surveys estimate the population to be about 2,450 animals in winter of 1998/99 (Mike Don Carlos personal communication).

A wolf management group of 35 groups and individuals has been working on a revised plan for wolf management in Minnesota. This management plan has been produced but the state has not implemented the plan.

In 1999, there were four projects using radio collars to monitor wolves in the state. The Department of Natural Resources also conducts winter snow tracking surveys.

Suitable habitat is located throughout most of the Lake Superior basin in Minnesota (Hazard 1982), but a population estimate for the basin is not available.

Ontario

In Ontario, the gray wolf is classified as a furbearer. Although there has been no effort to estimate the total number of animals in the province, wolves are considered to be common and their range encompasses the Lake Superior basin (Dobbyn 1994).

There have been two recent studies on wolf habitat use and population dynamics within the Lake Superior basin. In 1994, Pukaskwa National Park initiated a six-year predator-prey research initiative called “The P5 Project”. This project investigated the predator-prey dynamics and landscape change in the Greater Puksakwa Ecosystem. Twenty-seven wolves were radio-collared and data was collected on prey base, home ranges and territories. Habitat analysis was also investigated but most of the data collected was related to moose and woodland caribou requirements (Keith Wade personal communication). A second project based out of Marathon, radio-collared wolves from Neys Provincial Park to White Lake. This research examined habitat use and home ranges related to roads and landscape parameters and also the influence of garbage dumps (Krizan and Krizan 1997).

6.1.10.6 Canada Lynx

Canada lynx was formerly found throughout the Lake Superior basin, but its range has receded northward and it is now largely restricted to Ontario within the basin. The U.S. Fish and Wildlife Service proposed to list the Canada lynx as threatened under the Endangered Species Act in 1998.

Habitat is associated with cool coniferous forest in southern extensions of boreal forest into the U.S. (McKelvey and others 1999). Young, dense forest stands, where snowshoe hares are abundant, are critical, but lynx home range typically also includes mature forest with large woody debris for denning (Aubrey and others 1999).

Lynx populations fluctuate widely in response to snowshoe hare numbers. Following declines in prey, lynx wander from their core Canadian range into Minnesota, Michigan and Wisconsin. Particularly large incursions from Ontario into the states happened in the early 1960s and again in the early 1970s (McKelvey and others 1999).

The recession of lynx range in the U.S. is related to changes in forest conditions, loss of coniferous forest cover, trapping and roads. Timber management practices and fire suppression that lead to poor snowshoe hare habitat is detrimental to lynx. Increased roads threaten lynx due to increased access for trappers, and competitors such as coyotes and bobcats (Koehler and Aubrey 1994).

Michigan

Lynx were formerly widely distributed in the Upper Peninsula and Isle Royale, but virtually extirpated by 1938 (McKelvey and others 1999). The last record in the state was a trapping record from the early 1980s in Mackinac County. Lynx are now listed as endangered in Michigan.

There is good habitat, large continuous mixture of boreal and hardwood forest in the Upper Peninsula. (Kevin Dorn, personal communication), but habitat availability has not been quantified (Ray Rustem, personal communication). The Department of Natural Resources monitors trapping records, but does not conduct annual surveys.

The National Forest Service initiated a three-year monitoring program for cat species in 1999. The survey covers the West Block of the Hiawatha National Forest and will be expanded into the East Block of the Hiawatha Forest and the Ottawa National Forest in the winter of 1999/2000. Monitoring involves placing scratch pads, marked with catnip oil and then collecting hair samples for DNA sampling (Kevin Dorn personal communication).

Wisconsin

Lynx were listed as Endangered in Wisconsin in 1973, but removed from the list in 1997 due to lack of evidence of a breeding population (Wydeven and others 1999). Two lynx were killed in 1992; the first specimens collected since 1974 (Adrian Wydeven personal communication). Between 1991-1997 there were 10 reports of lynx with three observations in both 1992 and 1993. The Wisconsin DNR monitors lynx by conducting furbearer snow track surveys, wolf track surveys, reports of rare carnivores by public and survey of bobcat hunters and trappers. Lynx are considered to be very rare and probably not breeding in the state.

There has been no quantitative habitat survey, but habitat may be marginal with limited areas of boreal forest. Competition for prey with coyotes and bobcats may limit lynx distribution (Adrian Wydeven personal communication).

Minnesota

The status of lynx in Minnesota in the late 1800s and early 1900s is unclear due to possible confusion of early records with bobcats (McKelvey and others 1999). Lynx are a protected furbearer in Minnesota and the trapping season has been closed since 1984. Predator scent station and snow track surveys are conducted annually.

Lynx numbers in Minnesota reflect irruptions from Ontario and many records are assumed to be transient animals from Ontario, rather than a resident population. There were peaks in fur harvest returns in 1930, 1940, 1952, 1962 and 1973 (McKelvey and others 1999). In 1973, four hundred lynx were harvested in the state; in 1982, 42 lynx were harvested; and in the 1990s there has only been one record in Minnesota. These irruptions followed the snowshoe hare peak in each decade (Mike DonCarlos personal communication).

Potential habitat for a resident, breeding population within the Lake Superior basin is restricted to portions of Cook, Lake, and St. Louis counties (published and unpublished data collected by L. David Mech; cited in DonCarlos 1994). Habitat consists of areas with snowshoe hare and no bobcats.

Ontario

Lynx are distributed throughout the Ontario portion of the Lake Superior basin. Populations fluctuate with snowshoe hare numbers, but range has apparently been stable (Dobbyn 1994). Lynx have no official protection status, except their classification as fur-bearer.

Trapping records are the only quantitative population data available in Ontario (Neil Dawson, personal communication). In 1999, a survey was sent out to trappers in Ontario asking them to assess the current population of lynx and to give an opinion of population change in their area. In the five districts that border Lake Superior, 38 trappers responded to the questionnaire. Ten indicated that lynx were not present, 18 said lynx were scarce, seven stated lynx were common and three reported lynx abundant. Regarding population change, four indicated a decrease in population, three an increase and fifteen reported numbers about the same.

Lynx habitat supply hasn’t been quantified, but is probably not limiting, (Neil Dawson, personal communication).

6.1.10.7 Northern Brook Lamprey

Northern brook lamprey (*Ichthyomyzon fossor*) is a non-parasitic species. Its range includes parts of the Mississippi, Hudson Bay, and Great Lakes drainages. In the Lake Superior basin, it is known from a number of small streams in Ontario, Michigan and Wisconsin (Scott and Crossman 1973).

This species apparently does not move out to Lake Superior, but completes its life cycle in streams. Larval lampreys live in streambeds and feed on diatoms and protozoans. When the larvae hatch they make burrows in soft mud and spend six years growing. Following metamorphosis into an immature adult stage, they overwinter in the mud and emerge to spawn. Adults never feed and live for about a year before dying.

Northern brook lamprey is classified as vulnerable at the federal level in Canada (Lanteigne 1991). It is primarily a warm water species and may never have been common here. Larvae are subject to mortality by lowering water levels and increased siltation from erosion. Habitat may be limited by lampricide intended to control sea lampreys (Scott and Crossman 1973). Seventy-nine (45 United States, 34 Canada) Lake Superior tributaries have been treated with lampricide at least once during 1987 - 96. Of these, 53 (30 United States, 23 Canada) tributaries are treated on a regular (3-5 year) cycle (Klar and others 1996). Northern brook lamprey persists in untreated streams, and above barriers and in backwater areas which are not affected by the treatments (Lanteigne 1991, Royal Ontario Museum 1999).

6.1.10.8 Lake Sturgeon

A commercial sturgeon fishery had started by the early 1800's and the lake sturgeon population probably began to decline in the mid 1800's. By the late 1800's, the stock had declined dramatically. Low reproductive rate and slow growth made sturgeon vulnerable to over-fishing. Despite harvest restrictions implemented in the 1920's, sturgeon were commercially extinct in Lake Superior by 1940 (Waters 1987). Sturgeon populations have not recovered to historical levels (Hansen 1994).

Lake sturgeon prefer nearshore waters, 4 to 9 m deep, but are occasionally found at depths up to 43 m (Harkness and Dymond 1961). Shoals and embayments where benthic organisms are most abundant are the preferred foraging areas. Offshore waters (> 80 m) are not used. Spawning occurs in rapids in streams or in lakes over shallow rocky ledges and shoals where wave action keeps the eggs oxygenated (Scott and Crossman 1973). Larval fish drift downstream after hatching and typically remain in the stream or shallow waters for the first two years. Juvenile habitat requirements are poorly understood. Yearlings are sometimes found over flat sandy areas.

Nine Lake Superior tributaries currently have self-sustaining sturgeon populations (Table 6-25, Figure 6-51) (Auer 1999). Populations in all nine are reduced from historical levels. Another nine tributaries were historically used for spawning, but are not presently used.

The decline of sturgeon on Lake Superior was largely due to over-fishing, but habitat loss also contributed. Dams on spawning rivers created barriers for spawning migration and altered natural stream flow regimes during the spawning period. Unnaturally low water levels can kill embryos by exposing them to air. High flows can dislodge eggs or embryos from the substrate (Kempinger 1988). Adults are sometimes trapped by falling water levels (Sehler and others 1996). Deposition of bark and other debris from log drives buried spawning beds (Harkness and

Dymond 1961) and changes in land use along streams may have increased sedimentation and degraded water quality.

Dredging shipping channels in nearshore waters and harbor construction and shipping at river mouths contributed to decline in benthic organisms. Barriers constructed for sea lamprey treatments block migration of spawning adult sturgeon. Young sturgeon may be vulnerable to lampricide (Auer 1999).

A rehabilitation plan for lake sturgeon in Lake Superior (Auer 1999) recommends several habitat-related measures, including (i) protecting existing habitat (ii) restoring natural stream flow regimes through re-licensing criteria for hydroelectric dams (iii) providing passage past barriers and dams and (iv) minimizing the impact of sea lamprey control activities. Eight “critical management areas”, with suitable habitat and existing spawning stocks, are priorities for rehabilitation and protection (Figure 6-52). Other recommendations involve harvest, stocking and contaminants.

Information needs include (i) basic life history and abundance data (ii) descriptions and of nursery, juvenile and adults habitats (iii) quanitification and mapping of habitat.

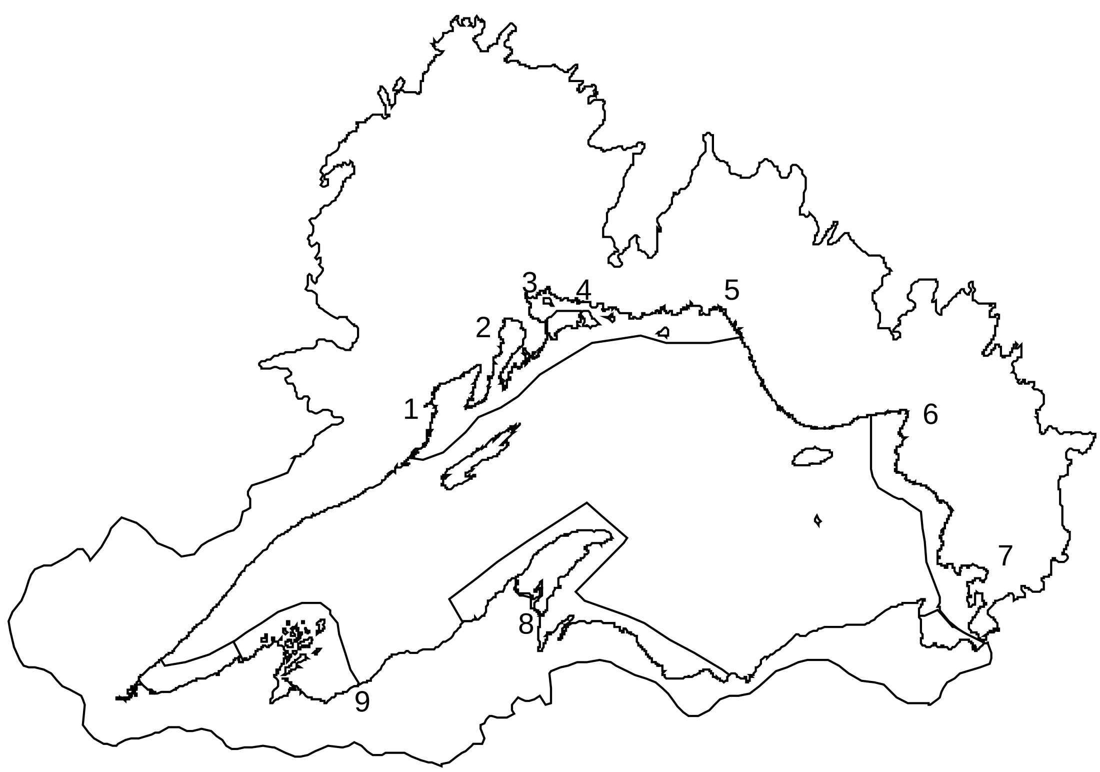


Figure 6-52. Critical management areas for lake sturgeon.
Numbers indicate self-sustaining spawning tributaries (Table 6-24) (Auer 1999).

Table 6-24 Tributaries with current or historical lake sturgeon populations (Auer 1999). Numbers refer to stream locations on Figure 6-52

Tributary	Status	Stressors
Pigeon River, MN/ON	Historical	
St. Louis River, MN/WI	Historical	Exotic species, loss of wetlands
Bad River, WI (8)	Current	Sedimentation, harvest
*Ontonagon River, MI	Historical	Erosion, loss of wetlands, regulated flow, dredging in lower river
Sturgeon River, MI (9)	Current	Dam, sediment loads, regulated water levels
Tahquamenon River, MI	Historical	Sedimentation, past logging practices, little spawning habitat
Batchewana River, ON	Historical	
Big Pic River, ON (5)	Current	
*Black Sturgeon River, ON (2)	Current	Dam, historical logging
Goulais River, ON (7)	Current	
Gravel River, ON (4)	Current	
Harmony River, ON	Historical	
Kaministiquia River, ON (1)	Current	
*Michipicoten River, ON (6)	Current	Dam, poaching, regulated water levels
Montreal River, ON	Historical	Regulated flow
Nipigon River, ON (3)	Current	Dam, regulated water levels
White River, ON	Historical	
*Wolf River, ON	Historical	Dam, lamprey barrier

* priorities for habitat restoration

Table 6-25 Embayments important to lake sturgeon in Lake Superior (Auer 1999)

Harbor/ Bay	Most Recent Observation	Stressors
Grand Portage Bay, MN	1995	
St. Louis, MN/WI	1997	
Chequamegon, MI	1997	
Bete Gris, MI	1993	Fishing
Huron, MI	1995	Siltation from poor stream crossings, logging practices, fishing
Keweenaw Bay, MI	1996	Treated waste management, treated paper mill effluent , fishing
Misery, MI	1995	Fishing
Munising Bay, MI	1991	Fishing
Whitefish Bay, MI	1997	Dredging for ship channel, contaminants, fishing
Batchewana Bay, ON	1997	Habitat loss
Black Bay, ON	1996	
Clark's Bay, ON	1997	
Goulais Bay, ON	1997	Bycatch of juveniles
Michipicoten , ON	1997	
Nipigon Bay, ON	1997	
Thunder Bay, ON	1997	Shoreline development
Wawanagon Bay, ON	1997	

6.1.10.9 Arctic Grayling

Arctic grayling (*Thymallus arcticus*) formerly inhabited the Otter River and Little Carp River in the Lake Superior watershed of the Michigan Upper Peninsula, as well as several streams in the Lower Peninsula (Hubbs and Lagler 1958). Relict populations of this arctic species were found in Montana and Michigan. Michigan populations disappeared by about 1936.

The extirpation of grayling from Michigan was caused by overfishing and habitat modification caused by logging (Eddy and Underhill 1974). Grayling spawn in the shallow water of small streams on sand and gravel substrate. This habitat is vulnerable to sedimentation, warming water and pollution.

Suitable habitat to support this species may no longer be present in the basin. The state of Michigan stocked grayling into several lakes and streams between 1987 and 1991 (Nuhfer 1992). Most stream populations disappeared within six months as fish dispersed downstream. Dams and warm water impoundments hampered survival and dispersal upstream. Some lake populations persisted where competition and predation by other fish species was low. Hooking mortality, illegal harvest, diseases and episodes of low pH were significant mortality factors (Nuhfer 1992). No reproduction has been detected. Introduction attempts in Minnesota (Musquash Lake and Twin Lake) and Ontario (Blue Lake) in the 1950s had similar results (Eddy and Underhill 1974, Scott and Crossman 1973).

6.1.10.10 Deepwater Ciscoes

Deepwater ciscoes consist of seven species, five of which inhabited Lake Superior: blackfin cisco (*Coregonus nigripinnis)*, shortjaw cisco (*C. zenithicus)*, bloater *(C. hoyi)*, shortnose cisco *(C reighardi)*, and kiyi (*C. kiyi)*. Two other species, deepwater cisco *(C. johannae)* and longjaw cisco *(C. alpenae)* were found only in the lower Great Lakes, but longjaw cisco is now probably extinct. Blackfin cisco is now probably extirpated from Lake Superior, although it is still found in Lake Nipigon and other inland lakes. All but blackfin cisco and shortjaw cisco were endemic to the Great Lakes (Scott and Crossman 1973). Three of these are listed federally in Canada: shortnose cisco (Threatened), shortjaw cisco (Threatened), and kiyi (Vulnerable).

Ciscoes formerly supported a substantial fishery in the Great Lakes. Fish were caught in deep-water gill nets, smoked and sold in the U.S. Fishermen targeted the larger, fatter species (blackfin, deepwater, and longjaw), until these stocks collapsed and then moved on to smaller species. The commercial cisco fishery declined through the 1940s and 1950s and collapsed by about 1960. Cisco populations increased though the early 1960s, apparently in response to decline of lake trout, an important predator (MacCallum and Selgeby 1987). Deepwater cisco populations declined again between the mid-1960s through the mid-1990s, possibly as a result of expanding lake trout population (Selegeby and others 1994, MacCallum and Selgeby 1987). Throughout this period, social factors, such as operating costs, demand and prices, caused some variability in catch. The bloater is the only species left in large numbers today (Hansen 1994).

Competition for food with introduced smelt and alewife may also have been a factor in their decline. Sea lamprey preyed on the larger cisco species (Lawrie and Rahrer 1972), but lamprey-caused mortality was offset by declines in their major predator, lake trout. Hybridization between closely related species may have hastened the decline of rarer species (Scott and Crossman 1973). Oxygen depletion resulting from eutrophication contributed to the decline in the lower Great Lakes, but was probably not a factor in Lake Superior (McAllister and others 1985, ROM 1998, Scott and Crossman 1973).

The present status of deepwater ciscoes is clouded by uncertain taxonomic status of the species and difficulty in monitoring. Hybridisation between species and with the ubiquitous lake herring apparently took place as stocks began to decline, resulting in populations with characteristics intermediate between their parent species. Their deepwater habitat also makes it difficult to determine population levels (Parker 1989).

Chemical and physical habitat changes do not appear to have had an adverse impact on these species. Deepwater ciscoes are protected indirectly in the Great Lakes through Canadian and U.S.

commercial harvest quotas for all deepwater ciscoes as a group. In Canada, they have the general protection given by the habitat sections of the Fisheries Act (ROM 1998). No recovery plans have been developed by U.S. or Canadian governments.

Kiyi

The Kiyi is still relatively common in Lake Superior, but is extirpated from the other Great Lakes (McAllister and others 1985). It is one of the smaller deepwater ciscoes, but otherwise very similar to the shortjaw cisco and the bloater (a common deepwater cisco). It occurs at depths of 35 - 200 m but usually at more than 100 m (ROM 1998). Changes in chemical habitat features, likely responsible for the extirpation of this species in the other Great Lakes, have apparently not resulted in significant habitat degradation for Kiyi in Lake Superior.

Shortjaw Cisco

Shortjaw cisco lives in deep waters (50-150 metres depth) where it can grow to a length of up to 35 centimetres. It is found in Lake Superior, Lake Nipigon and in scattered inland lakes from northern Ontario west to the Northwest Territories. It is extirpated from lakes Michigan and Huron (Houston 1988, ROM 1998). The USGS Ashland Biological Station is attempting to relocate the shortjaw cisco at known historical sites (Bob Kavetsky, personal communication).

Shortnose Cisco

Shortnose cisco is one of the smaller deepwater ciscoes and it inhabits shallower water than the other species (depths of 25-100 meters). It is the only deepwater cisco that spawns in the spring rather than fall and winter, although recently spawning has occurred in the fall in Lake Michigan (McAllister and others 1985, Parker 1988c, Webb and Todd 1995).

The historical status of shortnose cisco in Lake Superior is uncertain. Populations formerly reported from lakes Nipigon and Superior are now considered by some authorities to be shortjaw cisco. Shortnose cisco was known only from Lakes Huron, Michigan and Ontario, but may now be extinct (Bob Kavetsky, personal communication, McAllister and others 1985, ROM 1998, Scott and Crossman 1973). As with the other deepwater ciscoes, overharvest and sea lamprey predation, rather than habitat degradation, are probably responsible for its decline.

6.1.10.11 Pitcher's Thistle

Pitcher's Thistle (*Cirsium pitcheri*) is a Great Lakes endemic plant. Most of its range is on Lake Huron and Lake Michigan shores in Ontario, Michigan and Wisconsin. Habitat is open sandy beaches and dunes (White and others 1983).

On Lake Superior, Pitcher's thistle is known from two locations: Oiseau Bay in Pukaskwa National Park (White and others 1983) and Grand Sable Dunes in Michigan (Voss 1996). A thorough search of other suitable habitat on the Michigan shore failed to find any additional populations (Voss 1996).

Threats to Pitcher's thistle habitat include shoreline development, succession, shoreline modifications that change sand accumulation and overgrazing from deer. A long term monitoring program in Pukaskwa National Park, Ontario, found that the population dropped from a maximum of over 700 plants to less than 200 plants following the failure of an upstream beaver dam, causing a creek to re-route its channel. The population remained low for five years, but then rebounded in 1996 (Promaine 1999). Periodic disturbances of this sort may in fact improve habitat conditions for the species by reducing competition from other species. This population is relatively secure from human trampling and overgrazing from deer.

A recovery plan for Michigan populations is scheduled for release in 2000.

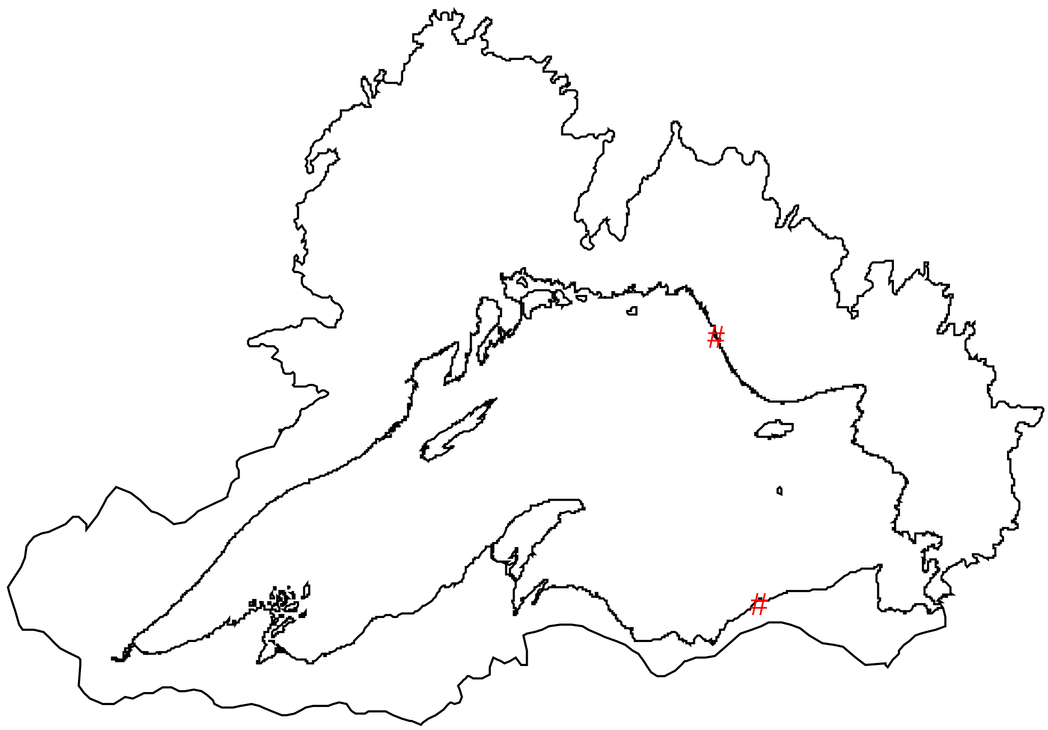


Figure 6-53. Pitcher's Thistle Population

6.1.10.12 Lake Huron Tansy

Lake Huron tansy *(Tanacetum huronense)* range extends from Maine and the Maritime Provinces, to Hudson Bay and northern Alberta. In the Great Lakes Region, it is found in northern Michigan, the Door Peninsula in Wisconsin and eastern Lake Superior shore in Ontario (Soper and others 1989, Voss 1996).

Its preferred habitat is active sand dunes and upper sand or cobble beaches within the wave zone during high water. It occasionally grows in limestone crevices. Depauperate plants sometimes persist on older stabilized dunes (Voss 1996).

Lake Huron tansy is known from the Michigan portion of the Lake Superior basin from Alger, Luce and Chippewa counties in the Upper Peninsula (Voss 1996). In Ontario, it is found at the Sand River mouth on the eastern side of the lake (Bakowsky 1998). Ontario authorities (Argus and others 1982 - 1987) consider Lake Huron Tansy to be a subspecies of *T. bipinnatum*, which is common and widespread on the James Bay – Hudson Bay coast and therefore not tracked.

6.1.10.13 Houghton's Goldenrod

Houghton's goldenrod *(Solidago houghtonii*) is another Great Lakes shoreline endemic. It typically grows in interdunal shoreline wetlands and low dunes and moist sandy beaches (Voss 1996). Fluctuating water levels of the Great Lakes play a role in maintaining its habitat. During high water, plant are submerged, but some plants survive the inundation and new seedlings establish on the moist sand (USFWS 1999).

Its primarily range is the northern shores of Lakes Michigan and Huron. In Michigan, it is found in the Lake Superior basin in Chippewa County (Voss 1996). Houghton's goldenrod is rare in Ontario, but is not known from the Ontario part of the basin (Oldham 1999, Semple and Ringius 1983).

Threats to Houghton’s goldenrod include trampling from foot and vehicular traffic associated with increased human activity on shorelines (USFWS 1999). Conservation efforts in Michigan include landowner contacts, monitoring, habitat protection in parks and reserves (USFWS 1999).

6.1.10.14 Ginseng

Ginseng (*Panax quinquefolius*) is at the northern edge of its range in the Lake Superior basin. Although relatively widespread in the southern parts of Ontario, Minnesota, Wisconsin and Michigan, its range within the basin is confined to Gogebic County in Michigan and adjacent Vilas County in Wisconsin (Argus and White 1984, Coffin and Pfannmuller 1988, Michigan Natural Features Inventory 1996). Ginseng is Threatened in Michigan, Special Concern in Wisconsin and Minnesota and rare (S3) in Ontario. At the federal level, ginseng is Threatened in Canada and Special Concern in the US.

Ginseng has declined throughout its range due to overharvest as an herbal medicine. This has resulted in loss of local populations and contraction of range.

Preferred habitat is rich hardwood forest with loamy soil, especially on slopes and ravines (Coffin and Pfannmuller 1988, Michigan Natural Features Inventory 1996).

Habitat related concerns include forest fragmentation (which inhibits natural reestablishment after harvesting), logging, heavy grazing by deer, and cattle grazing in woodlots (Michigan Natural Features Inventory 1996, Coffin and Pfannmuller 1988).

Ginseng export is regulated by the Committee on International Trade in Endangered Species (CITES). It is also protected by legislation in Michigan and Ontario.

6.1.10.15 Other Rare Plants and Animals

Numerous other plants and animals in the Lake Superior basin are rare at the state or provincial level. These include species with fewer than 100 occurrences in the state/province (i.e. “S1”, “S2” or “S3” following The Nature Conservancy rankings). Species that are rare in at least one state or province are listed in Addendum 6-A. It is important to note that some species listed here as rare are on the list because of habitat loss or population declines elsewhere in one or more of the states or the province. In some cases, such as with the kiyi, habitat in the Lake Superior area and populations of the species here are neither declining nor particularly degraded at the scale of the watershed. In these cases, habitat protection in the Lake Superior watershed is critically important.

Birds

Over 50 bird species are considered rare in at least one state/province. This includes species that are rare in the southern portion of the basin, but abundant in Ontario (Yellow-bellied Flycatcher, Tennessee Warbler, Swainson’s Thrush).

American White Pelican, although listed as endangered in Ontario, is increasing in numbers and expanding its range eastward. Pelicans now nest on Lake Nipigon in the Lake Superior basin, and may further expand their range since non-breeding birds are frequently seen on Lake Superior throughout the summer (Escott 1991, Bryan 1994).

Forest fragmentation and loss of mature forest cover threaten forest-dwelling birds such as cerulean warbler and red-shouldered hawk (WI DNR 1999). Protection of extensive mature forested tracts, especially mature floodplain habitats in Wisconsin and Minnesota will benefit these species.

Other threats to bird species include loss of wetlands (yellow rail, black tern), chemical contamination (merlin, osprey) and destruction of shoreline habitat (common tern).

Fish

Ten rare fish species are known from the Lake Superior basin (Addendum 6-A). Of these, northern brook lamprey, lake sturgeon, and deepwater ciscoes have been discussed in detail elsewhere in this report.

Silver lamprey (*Ichthyomyzon unicuspis)* and American brook lamprey (*Lampetra appendix)* live in similar habitats and are subject to similar stresses as northern brook lamprey.

Deepwater sculpin (*Myoxocephalus thompsoni*) inhabits deep lakes from Quebec to the Northwest Territories. Populations in Lake Superior and Lake Huron appear healthy, but the species is extirpated in Lake Erie and was only recently rediscovered in Lake Ontario. The Great Lakes populations are therefore classified as threatened in Canada (Parker 1988a). The decline of deepwater sculpin in the lower Great Lakes may be related to exposure to contaminants in lake sediments. Predation on larva by introduced fishes may have also played a role (Parker 1988a).

Paddlefish (*Polyodon spathula*) is known from a single record in the Lake Superior basin; a specimen from the Nipigon River in Ontario (McAllister and others 1985). Paddlefish is now extirpated in Ontario.

Three species of herring from the Lake Superior basin: Lake Ives cisco (*Coregonus hubbsi*), known from Lake Ives in the Huron Mountains of Michigan; Siskiwit Lake cisco (*C. bartletti*) from Siskiwit Lake on Isle Royale; and Nipigon Tullibee (*C. nipigon*) from Lake Nipigon and Black Sturgeon Lake have been described as full species (Hubbs and Lagler 1958), but are now generally regarded as members of the lake herring (*C. artedii*) "complex" (Scott and Crossman 1973).

Invertebrates

Rare invertebrates of the basin include 34 insect species and three mollusks. The distribution and abundance for some of these species is poorly understood and may be more common than their rankings suggest. Conversely, other rare species may be present, but not yet documented.

Several rare insects are associated with sand dunes and beaches. Beach dune tiger beetle *(Cicindela hirticollis)* inhabits sand beaches in the Ontario and Wisconsin parts of the basin. It is extirpated from some historical Ontario sites, possibly due to loss of habitat to shoreline development (Marshall 1999). Lake Huron locust (*Trimerotropis huroniana*) is endemic to the Great Lakes region. It occurs on sand dunes along the Lake Superior coast in from Chippewa to Alger counties in Michigan and in northeastern Wisconsin (Rabe 1999). Preferred habitat is extensive, sparsely-vegetated dunes with unstable sand and blowouts (Rabe 1999). Habitat loss from shoreline development and habitat degradation due to invasive weeds or disruption of sand movement cause populations to decline (Rabe 1999). Dune cutworm (*Euxoa aurulenta*) is a moth known from Whitefish Point in Michigan. It inhabits similar habitats and is threatened by similar factors as the Lake Huron locust (Cuthrell 1999a).

Reptiles and Amphibians

Two rare species of reptiles are known form the Lake Superior basin. Wood turtle (*Clemmys insculpta*) and Blanding's turtle (*Emydoidea blandingii*) are threatened in Wisconsin and Minnesota. Wood turtle is Special Concern in Michigan. They are at northwestern limit of their range in the Lake Superior basin.

Wood turtles inhabit small, clear fast streams with sandbars and meadows. In Michigan, they are distributed throughout much of the Upper Peninsula, but are restricted to small pockets of suitable habitat (Lee 1999). A significant threat to wood turtles is the disturbance of nesting areas by recreational use of sandbars and sandy banks by off-road vehicles, canoeists and anglers. Other threats include stream degradation, loss of forest cover along streams and overcollecting for the pet trade (Coffin and Pfannmuller 1988).

Blandings turtles live in rich wetlands near sandy uplands for nesting. Loss of wetland habitat, river channelization and dams are among the factors threatening populations (Coffin and Pfannmuller 1988).

Mammals

Three rare bat species: eastern small-footed bat (*Myotis leibii*), northern myotis (*Myotis septentrionalis*) and eastern pipistrelle (*Pipistrellus subflavus*) are known from the basin, but are at the northern and western limits of their ranges. Suitable caves for hibernating may be a limiting factor (Coffin and Pfannmuller 1988).

Pine marten (*Martes americana*) populations in the US portion of the basin declined in the late 1800s, and were thought to be extirpated from Minnesota and Wisconsin by the 1920s. Marten became re-established in northern Minnesota by the 1950s and are relatively common there now. Re-introduced populations have been established in northern Wisconsin (Wisconsin Dept. of Natural Resources 1999). Loss of mature, coniferous forest habitat related to logging and human settlement, as well as over-trapping, probably contributed to their decline (Coffin and Pfannmuller 1988). In Ontario, marten are relatively common and widespread. Recently introduced marten habitat guidelines call for maintaining large contiguous blocks of "core habitat" consisting of mature coniferous forest.

Cougar (*Felis concolor*) and wolverine (*Gulo gulo*) may have once inhabited the Lake Superior basin, but are apparently extirpated now. Occasional sighting of both species are reported, but these probably represent wandering individuals rather than a resident population. Some cougar sightings may be escaped pets. Cougar and wolverine require large tracts of habitat with low human disturbance. Persecution by humans and large scale changes in forest habitat probably contributed to their decline.

Plants

About 300 species of rare plants are found in the Lake Superior basin. This represents approximately 10 percent of the total number of plant species growing in the basin (Thunder Bay Field Naturalists 1998, Coffin and Pfannmuller 1988).

Many of these species are at the periphery of their range and have always been rare here. Some species are rare in one of the states/province, but common in others.

A breakdown of Minnesota's rare plants by habitat consists of 40 percent wetland species, 17 percent cliff/bedrock species, 15 percent prairie species, and 13 percent upland forest species. The rest are found in successional or transitional habitats. Most (78 percent) rare plant populations in Minnesota occur outside of protected areas (Coffin and Pfannmuller 1988).

Threats to rare plant populations include, logging, plowing native prairies, and water quality changes.

Some areas have higher concentration of rare plant habitats because of unusual features of climate, geology, and glacial history (Coffin and Pfannmuller 1988). Areas with concentrations of rare plant habitats are shown in Figure 6-54 and described in Table 6-26.

The moonworts (*Botrychium spp.*), consisting of several species of small ferns, deserve special mention. The majority of the global range of three of these species falls within the Lake Superior basin. They are false northwestern moonwort (*B. pseudopinnatum*), pale moonwort (*B. pallidum*), and pointed moonwort (*B. acuminatum*) (Wagner and Wagner 1993). Habitat for these species is primarily open sandy areas, dunes, and old fields.

Table 6-26 Rare plant habitats
Refer to Figure 6-54 for locations (Argus and others, Coffin and Pfannmuller 1988, Epstein and others 1997, Soule 1993)

	Area	Description	Example species
1	Northshore Islands and shorelines	Arctic-alpine disjunct species	*Oplopanax horridus, Carex atratiformis*
2	Sibley Peninsula	Cliff communities, calcium-rich bedrock	*Malaxis paludosa, Arnica cordifolia*
3	Stanley Prairie	Relict prairie community	*Erigeron glabellus, Stipa comata*
4	Nor'Wester Mountains and Minnesota Border Lakes	Open cliff base and rim communities	*Calamagrostis purpurescens, Senecio eremophilus*
5	Minnesota Northshore	Arctic-alpine disjunct species	*Sagina nodosa, Draba norvegica*
6	St. Louis River Estuary	Wetland communities	*Sparganium glomeratum, Petasites sagittatus*
7	Bayfield Peninsula	Boreal species, wetlands	*Armoracia lacustris, Huperzia selago*
8	Apostle Islands	Boreal and sub-arctic species	*Senecio indecorus, Pinguicula vulgaris*
9	Isle Royale	Arctic-alpine disjunct species	*Calamagrostis lacustris, Phacelia franklinii*
10	Keweenaw Peninsula	Coastal communities, arctic-alpine species	*Arnica cordifolia, Chamaerhodos nuttallii var. keweenawensis*
11	Eastern Michigan shoreline	Sand dune species	*Cirsium pitcheri, Tanacetum huronense*

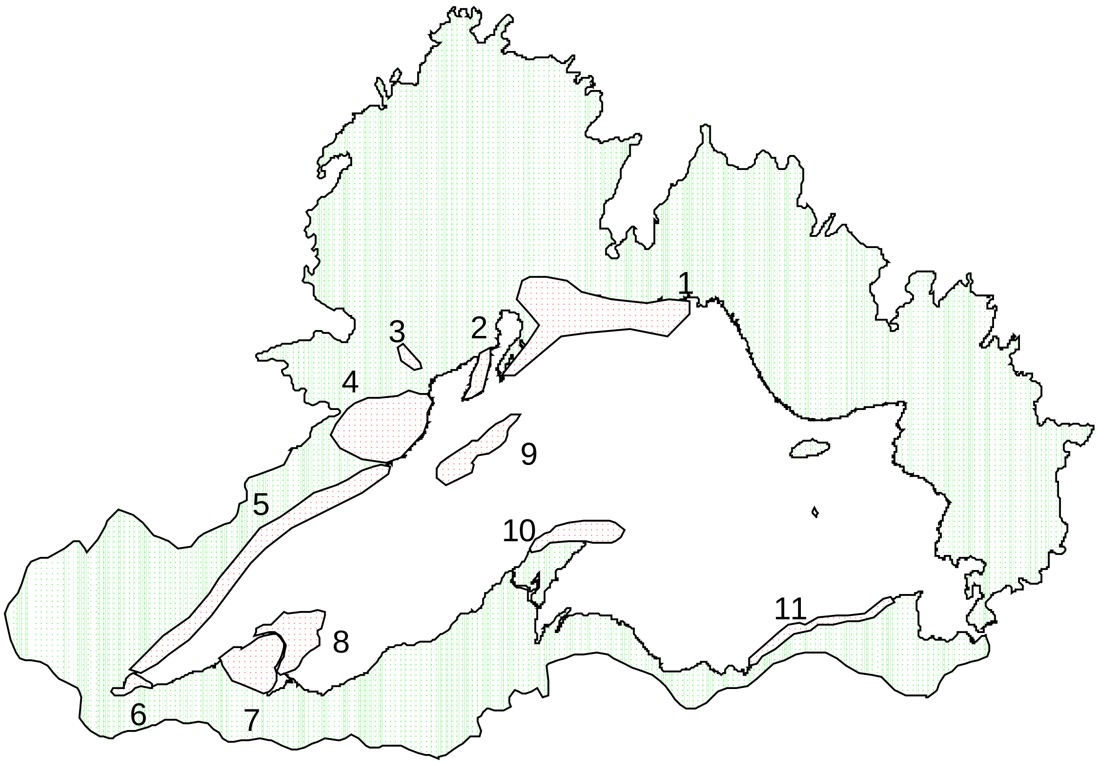


Figure 6-54. Rare plant habitats
Refer to Table 6-26 for descriptions

6.1.10.16 Rare Communities

The Lake Superior basin is home to several globally rare vegetation communities. Many are directly dependent on lake processes for their existence and support many of the rare species that inhabit the basin (Reid and Holland 1997).

This section describes some of the more prominent rare community types. A list of globally rare communities known from the Lake Superior basin is in Addendum 6-B. This list continues to be revised and updated as inventory work by the state and provincial agencies progresses.

Sand Dunes

Several communities associated with Great Lakes sand dunes are considered to be globally rare by the Nature Conservancy (Addendum 6-B). They form as sand is eroded from glacial sediments by waves and streams and moved along the coast and deposited. Dunes actively move as wind continues to move the sand.

Coastal dunes have a characteristic series of zones. Foredunes develop closest to the beach, where vegetation such as marram grass (Ammophila breviligulata) and American dune grass (*Leymus molis*) forces the winds to drop sand. Other plants such as beach pea (Lathyrus japonicus) and wormwood (Artemisia campestris) are established as the foredune grows. Trees and shrubs such as white spruce (Picea glauca), trembling aspen (Populus tremuloides), sand cherry (Prunus pumila), dogwood (Cornus stolonifera), and willows (Salix spp.) eventually gain a foothold (Reid and Holland 1997).

Interdunal areas lie protected from wind and waves behind the foredunes. These areas include globally imperiled communities called interdunal wetlands (pannes) which are calcareous, depressions kept moist by the water table. Vegetation in interdunal wetlands includes shrubby cinquefoil (*Potentilla fruticosa*), twig-rush (*Cladium mariscoides*) and baltic rush (*Juncus balticus*) (Michigan Natural Features Inventory 1999a).

Wooded dune and swale community complexes develop as post glacial uplift causes the lake level to recede, leaving dunes outside the direct influence of the lake and allowing new foredunes to form. Over several thousand years, this eventually results in a series of ridges and swales. Streams and groundwater keep the swales moist. Forest eventually develops on the older dunes. Jack pine, red pine and white pine are the dominant tree species, with white cedar and wet meadow in the swales (Michigan Natural Features Inventory 1999b).

The largest and most extensive dunes on Lake Superior are at Grand Sable Dunes National Lakeshore. Some dunes here are several hundred feet high (Reid and Holland 1997). Ontario's dunes are small, scattered cove dunes that develop in rocky coves of irregular coastines. The largest examples are in Ney's Provincial Park (0.9 km^2), at the mouths of the Pic and Sand rivers (0.4 km^2 each) (Bakowsky 1987).

Rare species found in dune habitats include Lake Huron Tansy, Houghton's goldenrod, Pitcher's thistle, Lake Huron locust, piping plover and dune cutworm.

Dunes are threatened by are residential development and roads which displace native species and disrupt natural sand migration. Off-road vehicles and other recreational use increase erosion. Sand mining, logging of forested dunes, and exotic plants are other threats (Michigan Natural Features Inventory, 1999a, 1999b).

Sand Beaches

Great Lakes sand beaches are considered to be globally rare by the Nature Conservancy (Addendum 6-B).

Sand beaches typically consist of a series of zones. The *lower beach* is scoured by waves and devoid of vegetation. The sparsely vegetated *middle beach* collects debris deposited by storms. The *upper beach* is vegetated with biennials and perennials such as wormwood and beach pea (Reid and Holland 1997). On Lake Superior, sand beaches are often associated with sand dunes, river mouths, and sheltered bays.

Lake Superior has a total of 665 km of sand beach (Canada 256 km; US 409 km), predominantly on the southern shore (Figure 6-55). The longest sand beach is a sand spit at the mouth of Chequomegon Bay in Wisconsin at 21 km in length. There are 161 sand beaches greater than 1 km long (Canada 60; US 101), but most are short, narrow stretches .

A number of rare flora and fauna are associated with sand beaches, many of which are shared by sand dune communities. These include Pitcher's thistle, Lake Huron Tansy, and piping plover. Many smaller beaches may be too small and isolated to support many of the plants and animals characteristic of the larger beaches.

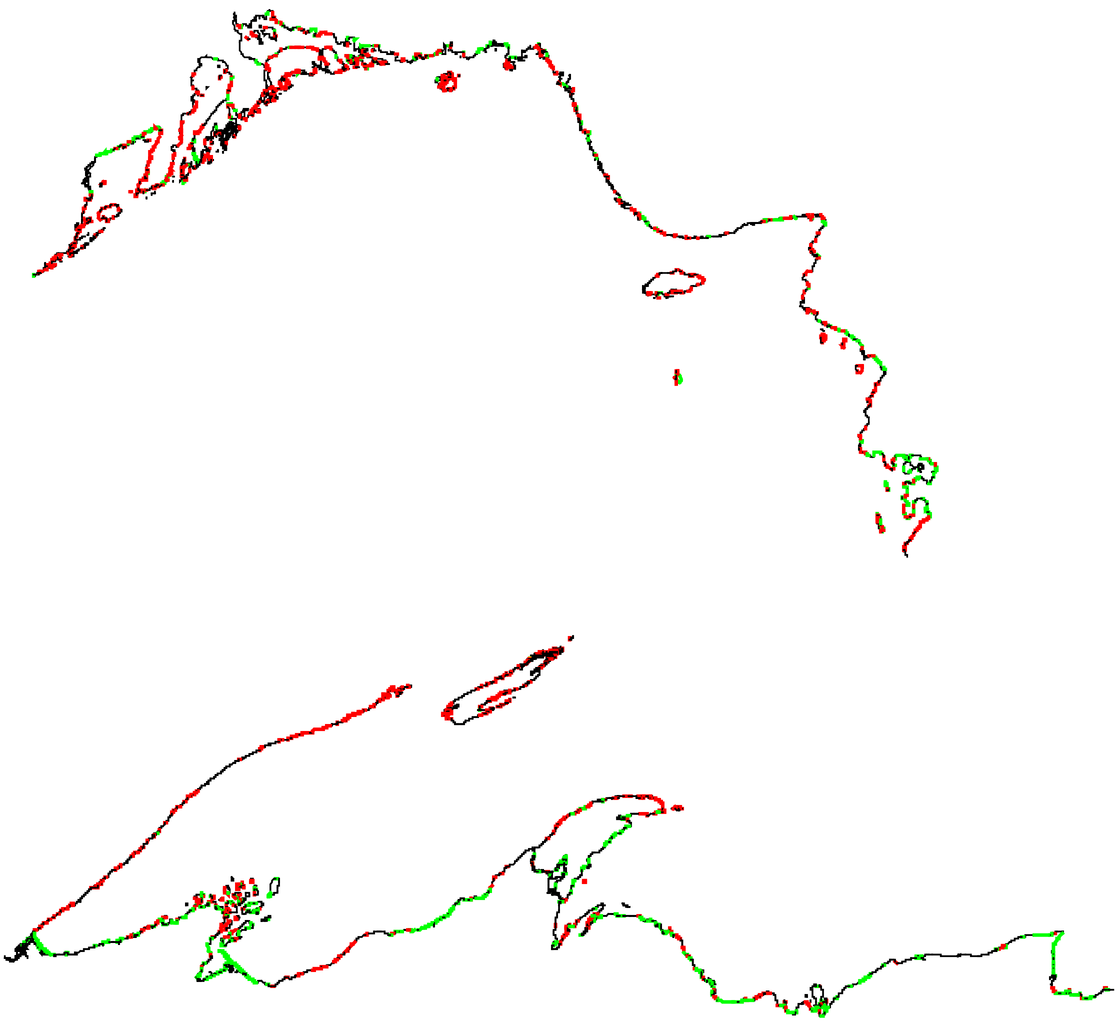


Figure 6-55 Sand (green) and cobble / gravel (red) beaches (compiled from U.S. EPA 1994 and Environment Canada 1993)

Most sand beaches depend on the natural processes of erosion, longshore sediment transport and sand deposition. When groins and other artificial shoreline structures interrupt these processes, the beach habitat is altered. Specialized beach plants can be outcompeted by other species as the environment becomes more stable (Reid and Holland 1997). Increased recreational use threatens piping plover and other sensitive species on some beaches.

Cobble and Gravel Beaches

Cobble and gravel beaches are common along rocky shorelines. Cobbles are rock chunks made up of limestone or other durable rock. Little vegetation is present due to exposure to severe wave and ice action and lack of soil. Great Lakes cobble / gravel beaches are considered to be globally rare by the Nature Conservancy (Addendum 6-B).

Cobble and gravel beaches are most common along the Minnesota north shore, Isle Royale, the Keweenaw Peninsula, the Sibley Peninsula, and islands along the Ontario coast (Figure 6-55). These beaches make up 958 km of the Lake Superior shore (Canada 541 km - includes “cobble”, “pebble” and “pebble and cobble” classes; US 417 km - includes “gravel” class)

Arctic-Alpine Communities

Arctic-alpine disjunct communities consist of plants that are isolated from their primary range in the far north or in alpine tundra. These communities are associated with the cold rocky shores of Lake Superior, where they have persisted since the retreat of the Wisconsin glacier.

Typical species include yarrow (*Achillea millefolia*), bearberry (Arctostaphylos uva-ursi), bluejoint grass (*Calamagrostis canadensis*), rocky mountain fescue (*Festuca saximontana*) and spreading juniper (*Juniperus horizontalis*). Other arctic-alpine disjunct species include mountain avens (Dryas drummondii), alpine chickweed (*Cerastium alpinum*), rock cranberry (Vaccinium vitis-idaea), butterwort (Pinguicula vulgaris), onion and garlic (Allium schoenoprasum var. sibericum), Norwegian whitlow grass (Draba norvegica), northern eyebright (Euphrasia husoniana), and alpine bistwort (Polygonum vivifarum) (Bakowsky 1998, Reid and Holland 1997). Over 400 species of lichen are associated with this environment . Two lichen species, Coccocarpia cronia and Umbilicaria torrefacta, are found only on the Susie Islands in western Lake Superior (Reid and Holland 1997).

Arctic alpine communities are usually associated with base-rich rocks such as basalt or diabase (Bakowsky 1998). Some of the best examples can be found at Sleeping Giant Provincial Park Ontario, the Slate Islands Ontario, the Susie Islands Minnesota, and Passage Island Michigan (Bakowsky 1998, Givens and Soper 1981, Judziewicz 1997).

Glaciere talus is another environment supporting arctic-alpine flora (Bakowsky 1996). This community is known from two canyons near Thunder Bay, Ontario. The steep walls block sun from reaching the canyon floor and allow ice to persist beneath talus boulders for most of the summer. The cold microclimate allows a number of arctic-alpine species to persist.

Arctic-alpine disjunct communities are generally protected from disturbance because they are inaccessible, but second-home development, recreational use, and trampling of vegetation have the potential for significant vegetative impact (Reid and Holland 1997).

Pine Barrens

Pine barrens are defined as areas of deep sands with scattered, pine trees and a ground layer of sedges and forbs. They have poor, sandy soils and frequent fires (Reid and Holland 1997). The flora often includes prairie species. Pine barrens are closely associated with oak barrens, sand barrens, savannahs, dunes, and prairies.

In the Lake Superior basin, pine barrens are found in the Bayfield Barrens Subsection (X.1) (Figure 6-24). This subsection covers 5,546 km^2 in Minnesota and Wisconsin, but pine barren makes up only a portion of the area. Soils are sandy glacial outwash (Albert 1995).

Pine barren vegetation consists of jack pine, red pine, junipers (Juniperus communis), shrubs such as sand cherry (Prunus pumila), little bluestem (*Schizachyrium scoparium*) and other grasses, sedges and forbs.

Less than 1 percent of northern Wisconsin's jack pine barrens remain today (Reid and Holland 1997). Large areas are managed as jack pine plantations for pulpwood. Fire suppression has allowed non-native species to invade and permitted the forest to succeed to more closed conditions. Recreational development is another threat (Albert 1995).

6.1.11 Other Important Species

6.1.11.1 Wild Rice

The "wild rice bowl" extends from Manitoba, through northwestern Ontario, Minnesota, and Wisconsin (Figure 6-56). Some populations in Ontario were probably introduced by native peoples many years ago (Aiken and others 1988). There have been more recent introductions to several locations in the eastern part of the Basin.

Wild rice habitat is shallow water in slowly-moving streams and inlets and outlets of lakes. It does poorly in stagnant water and fast moving streams. Soft organic material is the preferred substrate.

Wild rice is important to the ecology of lakes, streams, and shallow water wetlands. It helps maintain water quality by binding loose soils, tying up nutrients, and slowing winds across shallow wetlands. Wild rice is an important habitat component for many species. It provides wildlife, particularly waterfowl, with food and cover as well as brood cover for young birds.